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The 1995 Acquisition Research Symposium is the sixteenth in a series of conferences that began in 1972. These Symposia offer a dynamic forum for dialogue among key professionals working on vital issues facing the acquisition community. Attendees include senior officials, program managers, staff officers and researchers from the Department of Defense, federal civilian agencies, military, academe and industry.

This year's theme and subtheme reflect the future innovation and implementation in the acquisition process. "Acquisition for the Future - Imagination, Innovation and Implementation," and "Acquisition Reform: A Mandate for Change -- Reengineering the Acquisition Process," are the prevailing theme and subtheme discussed and examined throughout this publication. The papers published cover the latest research and development as documented by individuals involved in the many aspects of the acquisition process.

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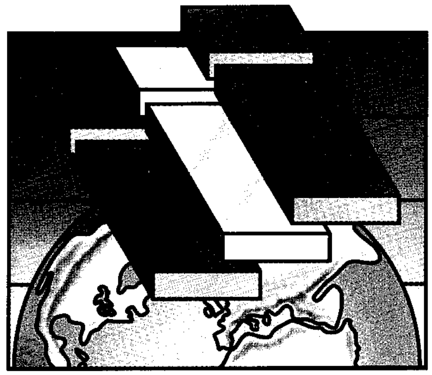

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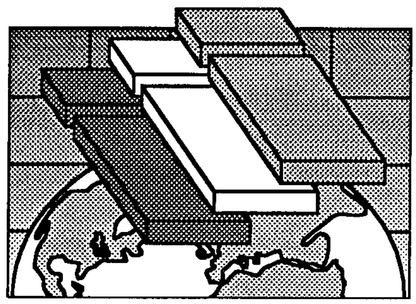

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Reengineering the Acquisition Process

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We invite you to take advantage of this publication, which expands upon Symposium presentations and introduces new authors and topics. Please note that the papers are published as received by authors (unedited) and the views expressed are those of the authors and do not necessarily reflect the views of the organization with which they are associated.

This "Book of Proceedings" is organized by twelve different topic area headings and alphabetized by the lead author's last name. All authors are listed in the author index with the corresponding page number of their research paper.

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ACQUISITION MANAGEMENT EDUCATION AND WORKFORCE

ETHICS AUDITS: EFFECTIVE TOOLS FOR TRAINING THE ACQUISITION WORKFORCE

Dr. Robert E. Bateman,
Weber State University

ABSTRACT

The purpose of this paper is to focus upon the need for improved awareness and sensitivity to ethical problems and issues which frequently confront the acquisition workforce.

The proper development and use of an ethics audit can be an invaluable tool in training and orienting the acquisition workforce about ethical problems and issues which often confront acquisition professionals. The ethics audit is a practical, flexible and imaginative document for assessing and introducing ethical problems and issues unique to an organization, whether public or private. This type of audit is a systematic and objective survey of ethical issues and provides yet another means by which, awareness of and sensitivity to ethical issues can be introduced in a training environment. The audit most frequently focuses upon the following key areas (but may be designed to introduce and explore many other appropriate and relevant ethical issues):

(a) The organization and organizational culture.
(b) Procedural, policy and regulatory issues.
(c) Individual behavior and conduct issues.
(d) Issues unique to "the system".

Well designed audits can be very effective tools in identifying, controlling and managing ethical problems within any organization. Such audits are particularly useful in providing ethical education for both new trainees and experienced acquisition personnel within the spirit and intent of the Packard Commission Work Force Survey and the Defense Management Review (DMR).

INTRODUCTION

One of the prime concerns of federal agencies in the acquisition process is the maintenance of a high level of organizational and professional ethics and integrity. The Federal Acquisition Regulation (FAR) specifically requires that contractors maintain a record of honesty and integrity to assure compliance with government regulations and thereby assure a high level of moral leadership by government contractors. Ethical problems in procurement are generally focused into two general areas. The first area is primarily concerned with business practices and personal conduct of individuals that is improper. The second area is directed toward organizational conflicts of interest arising from the award of contracts to individuals and organizations. 1 Violations of procurement ethics can be very costly to government contractors. In fact, violations can cost a company the contract itself. A company could lose all payments received under a contact and could ultimately result in criminal fines and jail time for corporate executives. Government contractors should take ethics violations very seriously.

In June 1986 the President's Blue Ribbon Commission on Defense Management, known as

the Packard Commission, issued its final report entitled A Quest for Excellence. 2 The Commission promulgated under Appendix A, Conduct and Accountability, what was known as The Defense Industry Initiatives on Business Ethics and Conduct, which established certain guiding principles for defense contractors. Under those principles contractors were to:

1. have and adhere to written codes of conduct;
2. train their employees in such codes;
3. encourage employees to report violations of such codes, without fear of retribution;
4. monitor compliance with laws incident to defense procurement;
5. adopt procedures for voluntary disclosure of violations and for necessary corrective action;
6. share with other firms their methods for and experience in implementing such principles, through annual participation in an industry-wide "Best Practices Forum"; and
7. have outside or non-employee members of their boards of directors review compliance.

The primary focus of this paper is on the evaluation and assessment of ethical conduct and practices. The ethics audit should be considered and utilized as one of several acceptable tools used in the determination of ethical conduct, practice and culture within the acquisition workforce and even beyond to the entire acquisition community and to be used as tools for training the acquisition workforce.

The Pentagon scandal of 1988, known by many as the "Pentagate" matter, 3 and the "Ill Wind" probe of the 1990's 4, which disclosed many problems in the use of consultants between U.S. companies and the Pentagon and raised many ethical issues and questions about competitive procurement and the abuse of inside information by the "revolving door" into, out of, and through the aerospace and defense industry. In view of the foregoing considerations one might naturally inquire what additional steps could or should Congress and the Pentagon take to manage and control ethical conduct in the aerospace and defense contract industry? It is, of course, most unlikely and improbable that such ethical problems will be totally eliminated. However, the challenge to continually train the workforce to be alert to ethical issues and overcome such problems must be continuous - even relentless.

GOVERNMENT PRINCIPLES OF ETHICAL CONDUCT

Within the Federal Government continued emphasis is being placed on ethical issues and problems. For example, Executive Order 12674, entitled, "Principles of Ethics Conduct for Government Officers and Employees", was issued on April 12, 1988, as amended. Thereafter the, "Code of Ethics for Government Service", was issued in accordance with 5 U.S.C.A. 7301, requiring the display of the "Code of Ethics for Government Service" in any Federal Government building in which at least 20 civilians are regularly employed. Subsequently under the provisions of Section 4, DOD 5500.7-R, the Department of Defense established "Department of Defense Human Goals," and Section 5 described "Ethical Values" considered as the core beliefs which are to be considered and used by DOD employees when making ethical decisions as part of their official duties. The primary ethical values identified are: honesty, integrity, loyalty, accountability, fairness, caring, respect, promise keeping, responsible citizenship, and pursuit of excellence. Section 6 sets forth a plan for official "Ethical Decision Making". The "ethical decision-making plan" includes the following: define the problem, identify the goal(s), list applicable laws or regulations, list the ethical values at stake, name all the stakeholders, gather additional information, state all feasible solutions, eliminate unethical options, rank remaining solutions, and commit to and implement the best ethical solution. The

foregoing code, values and plan provide a clear and comprehensive expression of the standards, principles, processes and procedures fundamental to ethical decisions and conduct within the Federal Government and the Department of Defense. Defense.5

MANAGING AND CONTROLLING ETHICAL CONDUCT WITHIN ORGANIZATIONS

It is appropriate to note that there is significant professional literature and documentation to support the proposition that ethical conduct and practices within an organization can indeed be substantially influenced and controlled.6 A code of conduct or code of ethics have long been proposed and utilized as an important aspect of creating, developing and controlling the conduct and behavior of personnel within an organization on both a domestic and an international scale. Codes of conduct are considered to be a clear statement of an organizations core values.7 Codes of conduct or ethics are considered to be the core or dominant values and beliefs and as such are often considered to be the very foundation of the corporate culture. For example Caterpillar, Inc., a huge multinational corporation, issued its first code of conduct which was entitled, "A CODE OF WORLDWIDE BUSINESS CONDUCT AND OPERATING PRINCIPLES, in October, 1974. The Chairman of the Board issued the following statement concerning the publication. "No document issued by Caterpillar is more important than this one." (underlining supplied). As Joseph W. Weiss so appropriately observed, "Ethical conduct in corporations must be a shared vision and practice that is actively communicated and modeled by executives, managers, and employees on an ongoing, daily basis." 8 J. L. Brooks offered the following recommendations to effectively implement ethical codes of conduct into an organizational culture: :(1) confidentiality should not be so restrictive that it prohibits employees from consulting with internal personnel regarding ethical questions; (2) a fair and objective hearing process should follow any report of an ethical problem or conflict; (3) assurance should be given to all employees that their rights with respect to discrimination, and notice and compensation in the event of layoff will be protected; (4) A section on employer rights or terms of employment should follow the employee rights section, in order to facilitate open communication and clarify expectations; (5) Executive support of the code of conduct should be demonstrated in the form of clear sanctions against those who violate it; (6) Conflicts of interest revolving around ownership interest in related concerns need to be addressed, as these conflicts can cloud judgments;(7) Consider any other ethical codes that influence employees in the corporation, and design the corporate code so as not to conflict with these external codes of conduct."9

ETHICS AND CONTROL SYSTEMS

Controls and control systems are considered to be an important aspect of strategic planning and management. In a broad sense strategic planning and management is vitally important to the success and perpetuation of the organization to "control the control system". 10 When focusing on the need for an effective means of establishing, managing and enforcing ethical conduct within an organization the code of ethics is considered to be a most effective tool. Three important aspects of controlling organizational ethics are considered to be organizational standards and codes of ethics, measurement of performance, and corrective action. 11

Considering the importance of ethics initiatives within the Federal Government and industry there are several strategic questions that should necessarily be posed. Should there be a "control system" i.e. a means of evaluating the system

regularly or on a periodic basis? The author proffers the view that every system should be reviewed and evaluated regularly. Is the system meeting the goals and objectives for which it was established? Is the system worth the commitment of time and resources expended? If not why not? If not what is required or necessary to return it to the required or accepted level of performance? What are the internal and external controls of the system? Is the system meeting established goals and expectations? Who or what process or system controls the control system?

"Controlling the control system - Control systems operating out of control can do more damage than good. Without proper care, a variety of problems can develop." 12 It is proposed that the ethics audit provides an effective means of evaluating the ethics "culture" or "system" within an organization.

In this particular regard attention should be given to what become known as the "COSO" report. The Committee of Sponsoring Organizations of the Treadway Commission (COSO) prepared a report entitled, "INTERNAL CONTROL - INTEGRATED FRAMEWORK" in September of 1992. Oversight of and representation on the Treadway Commission was provided by the: American Institute of Certified Public Accountants, American Accounting Association, The Institute of Internal Auditors, Institute of Management Accountants, and the Financial Executive Institute. The Project Advisory Council of COSO consisted of representatives of AT&T, IBM Corporation, Shell Oil Company, Household International, The University of Arizona, E.I. Du Pont de Nemours and Company, Nations Bank and Arthur Anderson & Co. The author of the report was Coopers & Lybrand.13 The report defines internal control as "a process, effected by an entity's board of directors, management and other personnel, designed to provide reasonable assurance regarding the achievement of objectives in the following categories: 1. Effectiveness and efficiency of operations, 2. Reliability of financial reporting, and 3. Compliance with applicable laws and regulations". Particularly emphasizes was the fact that "everyone in an organization has responsibility for internal control." 14

The report in stressing the important role and responsibility of management notes, "More than any other individual, the chief executive sets the "tone at the top" that affects the integrity and ethics and other factors of a positive control environment" and also that "all personnel should be responsible for communicating upward problems in operations, with the code of conduct, or other policy violations or illegal actions. 15 Among the factors reported to be important to the control environment was "integrity and ethical values" and provides that "Indications of lack of integrity or ethical values in any endeavors of top management--be it executive, operating or financial management - cast a pall over the reliability of the financial reporting process." 16

The "Evaluation Tools" portion of the report in noting the importance of integrity and ethical values and emphasized that: "management must convey the message that integrity and ethical values cannot be compromised, and employees must receive and understand that message." The following six points of focus were emphasized in the "Control Environment" section of the report:

1. Existence and implementation of codes of conduct and other policies regarding acceptable business practice, conflicts of interest, or expected standards of ethical and moral behavior.

2. Establishment of the "tone at the top" - including explicit moral guidance about what is right and wrong - and extent of

its communication throughout the organization.

3. Dealings with employees, suppliers, customers, investors, creditors, insurers, competitors, and auditors etc. (e.g. whether management conducts business on a high ethical plane, and insists that other do so, pays little attention to ethical issues).

4. Appropriateness of remedial action taken in response to departures from approved policies and procedures or violations of the code of conduct. Extent to which remedial action is communicated or otherwise becomes known throughout the entity.

5. Management's attitude towards intervention or overriding established controls.

6. Pressure to meet unrealistic performance targets - particularly for short-term results - and extent to which compensation is based on achieving those performance targets. 17

CODES OF ETHICS - CODES OF CONDUCT

Many companies attempt to provide oversight and governance of their ethical activities through the development and use of ethics codes or conduct codes. The author notes that references to "codes of ethics" and "codes of conduct" are often used interchangeably, a code of conduct to one organization may be a code of ethics to another. For convenience, and to avoid unnecessary confusion and repetition, future references will be to " codes of ethics". Codes of ethics have been identified by some as the means by which an organization can be vitalized. 18 It has been observed that over 90 percent of the Fortune 500 companies have a formal ethics code. 19 A survey of corporate executives indicated that codes of ethics are the most effective way to encourage ethical corporate behavior. 20 Among those organizations that have developed codes of ethics the ten areas of concern often included are: "1. Exercise of due care regarding stakeholders. 2. Confidentiality regarding private information. 3. Fidelity to special responsibilities. 4. Avoidance of the appearance of a conflict of interest. 5. Willing compliance with the letter and spirit of the law. 6. Acting in good faith in negotiations. 7. Respect for human well-being. 8. Respect for liberty and constitutional rights of others. 9. Procedures for contesting possible code violations. 10. Punishment for code violations." 21 The purpose for this type of code is to establish standards and to identify and emphasize acceptable codes regarding beliefs, values and conduct and as such set a moral tone for the organization. The most important topics often included in codes of ethics include "(1) general statements of ethics and philosophy; (2) conflicts of interest; (3) compliance with applicable laws; (4) political contributions; (5) payments to government officials/political parties; (6) inside information; (7) gifts, favors, entertainment; (8) false entries in books and records; (9) customer/supplier relations". 22

LEADERSHIP - SETTING THE "ETHICAL TONE"

It is important to note that the "ethical tone" within an organization is established through the actions and words of top management. 23 The organizational value system is most frequently established by the top executive in the organization. 24 Codes of Ethics should be published and "clearly state the firms core values." 25 Society has developed a higher level of expectation and recently many organizations have made substantial

commitments of time and capital in preparing rather complete and strict codes of ethics. 26 A number of multinational corporations have developed worldwide codes of ethics which they expect to be followed and applied by all of their employees throughout the world. A factor or consideration which is unique to this type of ethical application is that core values are which are emphasized. Core values are considered to be basic and so fundamental to the organization that they will seldom if ever be compromised.27

STAKEHOLDERS

Ethical analysis and evaluation of an organization must identify the stakeholders or the constituencies of that organization. 28 Stakeholder analysis is often considered to be a strategic management function of an organization. 29 A stakeholder is "any group that has an actual or potential interest or impact who has on an organizations ability to achieve its objectives.30 Among those individuals, activities and associated organizations often considered as stakeholders are: stockholders/owners, customers, employees, suppliers, board of directors, chief executive officers (CEOs) and other top executives, media, consumers, lobbyists, courts, governments, competitors, the public and society. 31 The stakeholder concept is considered to be particularly useful when considering ethical analysis because "it allows managers to gauge the impact of their decision on several affected groups." 32 Accordingly, it is suggested that any in depth analysis or study of ethical problems and appropriate methodologies for improving ethical awareness and solutions within an organization must necessarily consider and carefully identify its many and varied stakeholders or constituencies. The federal government is certainly a dynamic stakeholder. Under the U.S. Constitution (Article 1, Section 8) the government has many defined roles as "lawmaker, regulator, and enforcer over interstate and foreign commerce, taxes, duties, imports, tariffs, excises, the military, foreign affairs, bankruptcy, copyrights, and patent." 33

ORGANIZATIONAL CULTURE

Organizational culture is said to represent "the sum of the values of all the people within an organization. It is the normal way of doing things within an organization." 34 Organizational culture has also been defined as "a set of values, beliefs, goals, norms, and ways to solve problems that members (employees) of an organization share."35 Indeed, an important component of organizational culture is the ethical climate which is exists within the organization - the organizational conscience. The decision process within the organization determines whether problems are considered moral or immoral.36

Factors considered to be important to the ethical climate include codes of ethics, actions by top management regarding ethical issues, ethics policies, the influence of coworkers, and the opportunities for unethical conduct and behavior.37 The organizational culture is also considered to be "the shared beliefs top managers within a company have about how they should manage themselves and other employees, and how they should conduct their business." 38 To adequately measure and assess an organizations cultural values a culture audit may be performed to identify the cultural factors within the organization that significantly contribute to and create ethical conflicts.39

The author's review of literature on business and organizational ethics analysis has evoked a conclusion that the ethics audit of an organization should be but one means of evaluating the organizational culture. An organization should necessarily determine the extent to which the

organization's culture contributes to the ethical problems which are normally encountered. Are systemic ethical problems created by and inherent to the culture of the organization? A more comprehensive cultural evaluation would, in all probability require a cultural appraisal or audit.

ETHICS AUDITS

Historically audits have been considered as a means of evaluating the health or condition of the affairs of the an organization. The nature of auditing has been defined as ". . the accumulation and evaluation of evidence about quantifiable information of an economic entity to determine and report on the degree of correspondence between the information and established criteria. . ."40 Implicit within the foregoing definition is the fact that an evaluation must be made of quantifiable information to be measured against established criteria within an organization or entity.

The ethics audit presupposes that ethical performance should be reviewed and monitored to insure that ethical standards and expectations are being adopted and adhered to by a company, its organizational units and its employees.41 The ethics audit presupposes a measurement or evaluation of the ethical condition or health of the organization based upon established ethical standards. An ethics audit should be conducted in an orderly sequence. It should be comprehensive, systematic, independent, and periodic.

THE ETHICS AUDIT

Some of the appropriate questions addressed in ethics audits may include:

1. Who are the formal stakeholders?
2. Who are the informal stakeholders?
3. Who are the primary stake-holders?
4. What are the control systems?
5. Are all employees provided a copy of the organization's "code of ethics"or "code of conduct".
6. Has an ethics office been established?
7. Are ethics training and orientation programs available to all employees?
8. Are all employees required to have a basic training or orientation about the organization's ethics program?
9. Are current policies and procedures on ethics available to all employees?
10. Are company ethics standards and expectations clearly stated?
11. Is there a company ethics office, officer or ombudsman?
12. Is there a perceived recognition of top level executive encouragement and support for the ethics program for the organization?
13. Is your immediate supervisor informed of the company ethics policy and program?
14. What is the organization's policy and procedure concerning whistle blowers?
15. Have control systems for the ethics program been established?
16. Is there a procedure by which your ethics question can be heard and answered?
17. Is there a procedure by which your ethics grievances can be heard?
18. Is there a procedure by which your ethics grievances can be reviewed?
19. Is there a procedure by which your ethics grievances can be solved?
20. Is there an ethics peer review program?
21. What is the companies structure for hearing employee complaints?
22. Are ethical policies and procedures being enforced?
23. Is there a policy and procedure for identifying and resolving conflicts of interest?
24. Does the code of ethics apply equally to all employees, managers, and executives?

25. Is the code of ethics updated regularly?
26. Is the code of ethics available to everyone?
27. Has an ethical checklist been prepared and adopted throughout the organization?
28. Does the organization encourage questions and honest inquiry?
29. Is ethical conduct and compliance with the code of ethics truly encouraged?
30. Does the organization promote and reward ethical conduct and practices.?
31. Does the code of ethics address significant managerial issues?
32. Does the code of ethics fairly address the needs of our customers?
33. Does the code of ethics accurately and fairly represent the needs of our employees?
34. Is the quality of our products and services fairly represented to the public?
35. Is the organization fair?
36. Does the organization place too much emphasis upon profit?
37. Is the organization truly committed to quality service and excellent value.
38. Are you proud to be an employee and representative of this organization?
39. Does this audit ask the right questions?
40. Do you believe this audit equally applies to all departments?
41. Is this audit necessary and timely?
42. Are there other or more important questions that should be asked in this audit?
43. Should there be more emphasis on the "bottom up" rather than the "top down" approach to addressing ethical problems?
44. Is there too much focus on stereotypes instead of diversity and cultural understanding?
45. Is ethics training provided and are ethical question encouraged?

The sample "business ethics audit" provided in **EXHIBIT 1** ,as presented by O. C. Ferrell and John Fraedrich, provides a framework for preparing and implementing an "ethics audit" process or program within an organization.

ETHICAL PERSPECTIVES - PROPOSITIONS

Dr. Gene R. Laczniak has observed that, "Proper ethical behavior exists above the law. The law merely specifies the lowest common denominator of acceptable behavior."42 See **EXHIBIT 2** Dr. Laczniak's "Ethical Propositions". Similarly, it is important to understand that "ethics is not simply following the law. . . and that law and ethics are not identical.43 Furthermore, ". . . all laws are not necessarily morally defensible".44 "Simply obeying the law does not fulfill all ethical obligations . . . and does not and can not codify all ethical requirements".45

CONCLUSION

"Organizations desperately need managers who can accumulate and distribute power and who can solve societal conflicts of interest in a fair and equitable manner. Excellent managers are those who can balance or integrate the sometimes conflicting interests of owners, employees, customers, suppliers, local communities government officials, and the natural environment. In this sense, a manager's job is more similar to that of a judge and legislator than a technician."46

We may often conclude that most ethical problems are within the organization and may even be systemic in nature. Solutions to ethical problems are usually not external to the organization although external factors definitely contribute to and influence ethical problems. The solution to such problems are most often internal rather than external. Admittedly, one problem is based on how internal resources, attitudes, policies and programs are used in

responding to external factors or influences. Ethical analysis and problem solving is a never ending process. To solve the ethical problems of an organization it becomes necessary to stand back and look at the organization and its unique culture. Ethical standards and codes and organizational compliance and response should be frequently evaluated, and herein proposed - audited. What is the missions and goals of the organization? Are the missions and goals clearly defined and understood by the top managers and all employees? Is there one standard that applies to all who are associated with the organization or are there different and oftentimes conflicting standards? The ethics audit can be an effective tool of management if strategically analyzed, utilized and applied.

Ethical growth and maturity is an adaptive and progressive process which is similarly important to the growth and development of individuals and organizations. We do not suddenly become ethical anymore than we suddenly become experienced and wise. Our desire and commitment to be just, fair and ethical must be insatiable; our commitment must be deliberate and patient; and, our pursuit must be focused and relentless. As with the individual, so with the organization - we do not suddenly arrive, but we constantly become.

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EXHIBIT 1

Ethical Propositions

- Ethical conflicts and choices are inherent in business decision making.
- Proper ethical behavior exists on a plane above the law. The law merely specifies the lowest common denominator of acceptable behavior.
- There is no single satisfactory standard of ethical action agreeable to everyone that a manager can use to make specific operational decisions.
- Managers should be familiar with a wide variety of ethical standards.
- The discussion of business cases or of situations having ethical implications can make managers more ethically sensitive.
- There are diverse and sometimes conflicting determinants of ethical action. These stem primarily from the individual, from the organization, from professional norms, and from the values of society.
- Individual values are the final standard, although not necessarily the determining reason, for ethical behavior.
- Consensus regarding what constitutes proper ethical behavior in a decision-making situation diminishes as the level of analysis proceeds from abstract to specific.
- The moral tone of an organization is set by top management.
- The lower the organizational level of a manager, the greater the perceived pressure to act unethically.
- Individual managers perceive themselves as more ethical than their colleagues.
- Effective codes of ethics should contain meaningful and clearly stated provisions, along with enforced sanctions for noncompliance.
- Employees must have a nonpunitive, fail-safe mechanism for reporting ethical abuses in the organization.
- Every organization should appoint a top-level manager or director to be responsible for acting as an ethical advocate in the organization.

Source: From Gene Laczniak, "Business Ethics: A Manager's Primer," *Business*, March 1983, pp. 23–29.

EXHIBIT 2

Business Ethics Audit

Organizational Issues*			
YES	NO	1.	Does your organization include ethical concerns in strategic planning at the top level of the organization?
YES	NO	2.	Does top management have a mechanism to detect ethical issues relating to employees, customers, the community, and society?
YES	NO	3.	Does the organization communicate information about trade association or industry codes of ethics?
YES	NO	4.	Does the company have a code of ethics?
YES	NO	5.	Is there formal or informal communication within the organization about procedures and activities that are considered acceptable ethical behavior?
YES	NO	6.	Does the organization communicate its ethical standards to suppliers, customers, and significant others that have a relationship with the organization?
YES	NO	7.	Is ethics training provided for top management, middle management, supervisory, and other employees that are significant in the operation of the business?
YES	NO	8.	Do the company's manuals and written documents guiding operations contain ethics messages about appropriate behavior?
YES	NO	9.	Is there open discussion of ethical issues?
YES	NO	10.	Is there an ethics committee, department, team, or group that deals with ethical issues in the organization?

*A high number of yes answers indicates ethical mechanisms and procedures in place within the organization.

Examples of Specific Issues That Could Be Monitored in an Ethics Audit**			
YES	NO	1.	Are systems and operational procedures for individual employees to safeguard ethical behavior absent?
YES	NO	2.	Is it necessary for employees to break company ethical rules in order to get the job done?
YES	NO	3.	Is there an environment of deception, repression, and cover-ups concerning events that would be embarrassing to the company?
YES	NO	4.	Are participatory management practices that allow the discussion of ethical issues absent?
YES	NO	5.	Are compensation systems totally dependent on performance?
YES	NO	6.	Is there sexual harassment?
YES	NO	7.	Is there any form of discrimination—race, sex, or age—in hiring, promotion, or compensation?
YES	NO	8.	Are the only concerns about environmental impact legally required?
YES	NO	9.	Is concern for the ethical value systems of the community with regard to the firm's activities absent?
YES	NO	10.	Are there deceptive and misleading messages in promotion?
YES	NO	11.	Are products described in a misleading manner with negative impact or limitations uncommunicated to customers?
YES	NO	12.	Are the documents and copyrighted materials of other companies used in unauthorized ways?
YES	NO	13.	Are expense accounts inflated?
YES	NO	14.	Are customers overcharged?
YES	NO	15.	Is there unauthorized copying of computer software?

**The number of yes answers indicates the number of possible ethical issues to address.

"Business Ethics Audit", O.C. Ferrell and John Fraedrich,
Business Ethics: Ethical Decision Making Cases, Second Edition.

ARMY PROGRAM MANAGERS: A COMPETENCY PERSPECTIVE

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ABSTRACT

This paper summarizes a recently completed Masters Degree research project at the Naval Postgraduate School (NPS)[1]. The project characterizes the competencies which distinguish the most successful Army program managers (PMs) from their peers. The research results are based on survey data obtained from program executive officers (PEOs), their deputies, program managers, and acquisition students, as well as interviews conducted with selected program managers. Competency rankings from the survey are compared to the original competency research conducted by the Defense Systems Management College (DSMC) in the late 1980s. The study concludes that the majority of the original DSMC competencies are still valid but new competencies also emerged which may reflect the changing program management environment of the 1990s. The program management curricula of DSMC and NPS were also examined for their coverage of the most important competencies. Although the competencies are generally addressed by both curricula, the study recommends an additional block of instruction on "Marketing for Program Managers." This block would focus on how successful program managers apply the most important competencies in the current acquisition environment.

INTRODUCTION

What are the characteristics that distinguish the most successful program managers (PMs) from their peers? The results of one of the most extensive studies of successful PMs was published in a 1989 article entitled "The Right Stuff: Results of DSMC's Program Manager Competency Study."[2] The ordinal DSMC study identified 16 competencies in its PM Job Competency Model. The DSMC study defined a competency as an attribute of a PM that underlies effective performance. The DSMC PM Job Competency Model included ten core competencies common to all PMs, and six competencies that distinguished the most successful PMs from their contemporaries.[3] An updated version of the DSMC competency survey was developed and administered to over 220 acquisition personnel with an 80% response rate. The survey asked each respondent to review the 27 competencies from the original DSMC survey. They were then asked to select the nine most important characteristics of the "ideal" PM, and the nine least important characteristics.

Initially, surveys were administered to Army PEOs and their deputies. These senior acquisition officials were asked to identify those PMs who they thought best fit the competencies that they had previously identified as being most important for an "ideal" PM. They selected 18 of the 34 Army PMs as being most successful and 16 PMs as average. [It is important to understand that not being selected as one of the most successful PMs did not mean that the remaining PMs were poor performers. For the purposes of this study, it was assumed that anyone selected to become a PM must be a competent (i.e., at least an average) performer.] Of the 25 PMs who

TABLE I

COMPARISON OF DSMC AND NPS COMPETENCIES

ORIGINAL DSMC COMPETENCY MODEL	REVISED NPS COMPETENCY MODEL
SENSE OF OWNERSHIP(*)	INNOVATIVENESS
LONG-TERM PERSPECTIVE	POLITICAL AWARENESS
MANAGERIAL ORIENTATION	SENSE OF OWNERSHIP
POLITICAL AWARENESS(*)	RELATIONSHIP DEVELOPMENT (*)
OPTIMIZING(#)	LONG TERM PERSPECTIVE
RESULTS ORIENTED	COACHES OTHERS(*)(@)
SYSTEMIC THINKING	RESULTS ORIENTED(*)
INNOVATIVENESS	MANAGERIAL ORIENTATION
FOCUS ON EXCELLENCE	ACTION ORIENTED
ACTION ORIENTED(*)	PROACTIVE INFORMATION GATHERING
RELATIONSHIP DEVELOPMENT (*)	SELF CONTROL (*)(@)
PROACTIVE INFORMATION GATHERING	SYSTEMIC THINKING
STRATEGIC INFLUENCE	FOCUS ON EXCELLENCE
INTERPERSONAL ASSESSMENT(*)	CRITICAL INQUIRY
CRITICAL INQUIRY	STRATEGIC INFLUENCE
ASSERTIVENESS(#)	INTERPERSONAL ASSESSMENT(*)

NOTE:
(*) Indicates a competency that distinguishes the most successful PMs.
(@) Indicates a competency that was added in the revised PM Job Competency Model.
(#) Indicates a competency that was deleted in the revised PM Job Competency Model.

Pentagon, the test community, contractors, and the user. Many PMs stated that they were able to obtain positive results for their programs just by working the relationships that they previously established with various agencies. As one PM stated: *This may sound like the "good-old-boy network," which it is, but the Army is personnel and staff intensive, so interpersonal relationships, the ability to work with others, is a must.*

4. Self Control (*): Remaining calm and unemotional in stressful situations.

Several of the PMs that were interviewed said that they knew program managers who were "screamers" and who got angry very quickly. While this may work in the short term, PMs who resort to such actions will never be able to count on those people to "bend over backwards for them in the long term." Most PMs agreed that there is nothing wrong with losing your temper as long as you understand beforehand the consequences of that action.

5. Innovativeness: Champions and pushes new ways of meeting program requirements.

There are no cookbook answers in the acquisition business: if there were, the Army wouldn't need PMs. Program managers are hired to "manage unique situations effectively." It is important for a PM to remember that the solution that worked yesterday may not work tomorrow. The

responded to the survey, 11 were rated successful and 14 were average.

REVISED COMPETENCY MODEL

The NPS survey validated 14 of the 16 competencies identified in the original DSMC study. A comparison of the original and revised Job Competency Models is provided in Table 1. Competencies are listed by rank order of importance (from survey data) for each model.

The results of the NPS study indicate that all PMs share 11 competencies. Additionally, there are five competencies which appear to distinguish the most successful PMs. In order to gain further insight into these competency rankings, the seven most successful PMs (who were selected by more than one PEO) were interviewed. The 16 competencies from the revised Job Competency Model, their definitions, and insights gained from these interviews are provided below. [Competencies designated with an (*) are the ones that distinguish the most successful PMs from the their peers.]

COMPETENCY DEFINITIONS

1. Political Awareness: Knows who influential players are, what they want, and how best to work with them.

Politics affects every aspect of an Army program. Whether this is right or wrong, PMs must operate in this environment. As one PM put it: *If you are not politically astute about the Pentagon, Congress, or other Government agencies, you will never understand their agenda, your program will fail, and you will never know why it failed.*

Program managers learn very quickly how politically sensitive their programs are. It is important for PMs to understand that trade-offs have been made at the Army, DoD, and Congressional levels just to keep their programs viable. As one PM stated: *You may have to concede many times on small issues just to keep your program alive; lose the battle to win the war.*

2. Coaches Others (*): Providing others with performance feedback and suggestions to improve their capabilities.

As the Acquisition Corps evolves into a profession, the ability of junior officers to learn from their superiors will help them avoid many of the mistakes of the past. If PMs do not train the people who will one day fill their positions, they are doing a disservice to the Acquisition Corps, the taxpayer, and the individual. As one PM stated about one of his junior officers: *This guy is going to be a program manager one day; it's my job to coach him and let him develop to his potential.*

3. Developing Relationships (*): Spends time and energy getting to know program sponsors, users, and contractors.

Program managers have daily interfaces with a variety of people from outside their organizations. Each of these people will have their own agenda, priorities, and resource constraints. To be successful, program managers must be able *...to pick up a phone, explain what they need done, and because of the relationship they have established with these folks, have them respond.*

Building relationships does not happen overnight. PMs must take the time to visit and cultivate both old and new relationships with key personnel affecting their programs. These key personnel include people from the

primary responsibility of the PM is to find out what will work, and do it.

6. Results Oriented (*): Evaluates performance in terms of accomplishing specific goals or meeting specific standards.

One of the most important parts of the PM's job is making each program work and getting it fielded. As one PM stated: *Everything you do [as a PM] has got to be focused on results, results, results.* To get a program fielded, PM's must put "marks on the wall;" otherwise, events will dictate the course of the program. By focusing on results, PMs have a way of setting priorities and measuring the results of their programs against a specific standard.

7. Sense of Ownership/Mission: Sees self as responsible for the program; articulates problems or issues from a broader organizational or mission perspective.

Sense of Ownership is important from the perspective that one of the primary roles of PMs is to be their program's number one advocate and cheerleader. One PM put it this way: *If a PM is not out there leading the charge for his system, then he is probably doing a disservice to the taxpayer and the soldier.*

A negative aspect of this competency is that Sense of Ownership might imply, to some people, that the program belongs exclusively to the program manager. PMs should never become personally attached to their programs. They must keep the attitude that "...if the Army says they don't want the program, I personally don't want it." This allows them to establish the credibility of their programs based on each program's capabilities, without others viewing their actions as personal or vindictive. So PMs must be committed to selling the Army's program, not their personal program.

8. Long Term Perspective: Anticipates and plans for future issues and problems.

Most PMs agreed that the most commonly used tool for focusing on the long term perspective was the DoD six year budget process. One PM stated that: *If I had a [financial] problem today, I couldn't fix it in 1994 if my life depended on it, without severe turbulence, because I don't have the money to do it. The 1995 budget is essentially locked...it would take a miracle to change it now. So 1996 is your first year to impact. Without a long term perspective, I can't do that.*

According to current PMs, what distinguishes successful PMs from their peers is their ability to identify a crisis that will not occur until two years from now. Successful program managers must be able to shape events so that the crisis is manageable when it does occur.

9. Managerial Orientation: Gets work done through the efforts of others.

Program managers don't have time to do everything themselves. A PM's job is to "steer the ship," keep their action officers "heading in the right direction," and then empowering their subordinates to complete the mission.

One of the key aspects of Managerial Orientation is that it forces PMs to take the time to understand the strengths and weaknesses of their personnel. By understanding subordinates' capabilities, the PMs are able to place those personnel into

positions that maximize their strengths and minimize their weaknesses. By empowering their subordinates to accomplish specific missions, PMs have the time to focus their efforts on resolving the major problems before they become crises.

10. Action Oriented: Reacts to problems energetically and with a sense of urgency.

A program's performance is directly tied to how action oriented its PM is. To quote one program manager: *You don't need me if I'm not action oriented, because I'm paid to respond to a crisis.* The very nature of the PM's job means that they must deal with crises on a day-to-day basis.

Most of the examples cited by PMs concerning this competency focused on dealing with crises which pertained to the program's budget. One PM put it this way: *When the Pentagon calls and says that you have two hours for an answer, they are not throwing "wolf bait." You have got two hours to get them an answer before the window of opportunity closes. If you don't respond, you have just lost the battle - battles which normally equate to money.*

11. Focus on Excellence: Strives for the highest standards regardless of circumstance.

Many of the PMs felt that it was easy for people to say that they focus on excellence, but it was much harder to actually do it. As one PM stated: *I've never been in a situation in this business where there was an excellent solution. Everything is a trade-off.* So PMs strive to provide the user and the taxpayer with the best product they can within the constraints of cost, schedule, and performance.

12. Strategic Influence: Builds coalitions and orchestrates situations to overcome obstacles and obtain support.

Strategic Influence plays an important role in the external environment of a program. It affects how a program is funded, staffed, and fielded. Program Managers can't get their programs fielded by themselves. They must be able to build coalitions and partnerships, and be able to effectively use them to weigh in for their program when the time comes. One PM said that the key to building an effective coalition was to: *...come across as a sincere and honest person, yet willing to stand up for what you think is right, then they will probably be willing to compromise if you don't have a dogmatic approach to things.*

13. Critical Inquiry: Explores critical issues that are not being explicitly addressed by others.

PMs are responsible for understanding the political environment within which their programs exists. Their skill in understanding other people's agendas, building coalitions, and getting their programs fielded depends on their ability to ask the hard questions "up front and early." It is this Critical Inquiry, asking the "what if" questions, that allows the PM to discover the rationale behind certain answers. As is often the case, PMs can gain more insight from understanding the rationale than from the answer itself.

14. Systemic Thinking: Organize and analyze problems methodically.

The acquisition of a major weapon system is a complex process. The PM must not only coordinate the program through its current phase, but also plan for the program's growth throughout its life-cycle. The PM

must be able to methodically lay out a plan that will allow the program to get through a particular event as well as future events.

15. Proactive Information Gathering: Systematically collects and reviews information.

Very few people are willing to come up and tell you that they have a problem. When something goes wrong, people will tend to "sit on the news, trying to make it better, or hoping the bad news will go away." One of the PMs put it this way: *If a PM is not proactive, he cannot get his job done. A PM that is not out finding his problems is in the reaction mode. If I am reacting to a problem, it means it's already here. Already here means I better have the financial ability to do it, which means it's too late. If I'm reacting to a problem, it means that it's probably already over my head.*

In short, an effective PM must find out about problems before they happen.

16. Interpersonal Assessment (*): Identifies specific interest, motivations, strengths and weaknesses of others.

Program managers must be cognizant of their own strengths and weaknesses as well as those of their subordinates. One PM stated that the reason he hired a specific deputy was to balance his own weaknesses: *I am weak in program management, budgeting, cost estimating and contract negotiating. He is an expert in those areas. This balances my own style of management by walking around.*

By understanding their subordinates' capabilities, PMs will be better able to manage their programs. They will understand when to get out of their way and when they are in danger of "focusing on a few trees in the forest." In short, interpersonal assessment is the ability to understand and work with people.

RECOMMENDATION

Analysis of the DSMC and NPS curricula revealed that both schools provide an awareness of the 11 core competencies identified in this research project. However, more emphasis is needed especially on the five competencies that distinguish the most successful program managers. Since DSMC and NPS curricula are based on functional areas, internal curricula changes are not recommended since they may alter the functional course baselines required for Acquisition Corps Certification. Instead, DSMC and NPS should develop a block of instruction specifically devoted to the set of program manager competencies and how they are integrated into the functions PMs must perform. This instruction would include real examples of what happens to program managers who understand, or fail to understand, particular competencies.

The new course which could be entitled "Marketing for Program Managers" could be integrated into the DSMC and NPS curricula as an elective or seminar program. It would help ensure that future program managers are provided more specific guidance on how to become successful in their dynamic career field. It would also ensure that the PM competencies are considered as educational programs related to the acquisition process evolve into the future.

CONCLUSION

The primary role of an Army PM is to direct the development and production of a weapon system within the constraints of cost,

schedule, and performance. To successfully accomplish this, PMs must exhibit certain competencies. Their ability to integrate these competencies into the management of their programs plays an important part in the success of each program. The revised Job Competenciey Model identifies 16 competencies that current Army major system PMs highlighted as being important to successful program management. While these 16 competencies can't be seen as a "cook book" solution for future PMs, they do provide a "blue print" of the leadership and managerial skills needed to become an effective PM in today's turbulent acquisition environment.

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Assessing Acquisition Management Competencies Using Experiential Classroom Exercises

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ABSTRACT

The passage of the Defense Acquisition Workforce Improvement Act and creation of the Defense Acquisition University have resulted in major changes in the career development and training of the Defense Acquisition Workforce. Hundreds of competencies (learning objectives) have now been identified for the designated acquisition career fields. Many of these competencies go beyond the knowledge base to application and synthesis levels of Bloom's Taxonomy of Learning. This large number of "performance-based" learning objectives will not only require new classroom teaching and learning approaches, but also new approaches to assess student progress and learning outcomes. This paper will focus on application of experiential exercises for both learning and assessment of higher level acquisition management competencies. Example exercises will be cited from team projects, management games and simulations currently used at DSMC. Through such exercises, students learn by demonstrating both their acquisition knowledge and their ability to act on this knowledge in complex situations which mirror those they will face in their real jobs.

EXPERIENTIAL EXERCISES

An experiential classroom exercise is an interactive experience emphasizing learning by doing, and providing time for personal reflection and feedback from both the instructor/facilitator and other students. Frequently these exercises involve students in a variety of management roles, each related to key issues undergirding the acquisition scenario. Each role contains extensive information on past activities, correspondence on current practices, decision situations, and critical issues faced in the scenario. Through observing such behaviors as problem solving, decision making, and priority setting, students are provided feedback on their behaviors, and are then able to make self-assessments as to the effectiveness of such behaviors.

Experiential exercises provide realistic and focused, but neutral, environments. They allow students to hone in on both their acquisition knowledge and management style as strategic and tactical issues emerge--issues which involve coordination and integration among individuals, work teams and outside stakeholders. These are the same realities that acquisition managers continue to deal with as shrinking resources and revised objectives force them to face the paradox of balancing increasing demands with increasing constraints in an ever changing climate.

Experiential exercises attempt to recreate real world acquisition management situations as closely as possible. The goal is to engage students in the active process of learning by doing. Using multiple roles with different information and perspectives, these exercises effectively mirror the complexity inherent in real life experiences. At the same time, students are afforded extensive freedom in the behaviors and actions they choose in response to scenario issues. This insures that follow-up discussions and feedback sessions relate to the students' actual managerial styles.

The major learning premise underlying experiential exercises is that each student is responsible for his or her own learning coming out of the exercises. Students are therefore encouraged to reflect on their own judgment and actions during the exercise, willingly take part in the debriefing sessions, and give and receive feedback.

The key characteristics of experiential exercises are summarized in Figure 1. The value of these exercises in training is best expressed by Henry Mintzberg in *The Nature of Managerial Work:*

> Cognitive study is useful but generally sterile. Learning is most effective when the student actually performs the skill in as realistic a situation as possible and then analyses his performance explicitly. One cannot learn to swim by reading about it. One must get into water, splash around, and practice various techniques with advice from someone who knows what skills swimming requires. Eventually, with sufficient feedback, he learns to swim. The same holds true for many management skills. The student must be immersed in the milieu; he must practice the skill; and he must receive constructive feedback on his performance from someone who understands the skill.

COMPARISONS

This section offers a brief comparison of experiential exercises with their closest relatives in educational methodology: case studies and computer-based simulations. Experiential exercises emphasize learning through doing, as compared with case studies which focus on the application of cognitive learning and computer-based simulations which focus on analysis-based learning. Case studies with their emphasis on application and synthesis in the cognitive domain require students to function in an almost consultant-like role. Computer-based simulations cause students to compete within the constraints of a programmed model. Effectiveness is measure against the model's design rather than through the interactions and behaviors of students. The similarities and differences between these learning vehicles are summarized in Figure 2.

DSMC EXAMPLES

DSMC uses experiential exercises throughout its curriculum. Several of these simulations are listed in Figure 3. They range from short, narrowly-focused activities to complex, elaborately-staged exercises spanning several days. Each exercise will be briefly discussed in this section. Further information on these exercises can be obtained from the DSMC Education Department.

Gold of the Desert Kings is a half-day exercise to develop goal setting and team building skills. Students form teams and compete to be the first to race across the desert, mine gold in the mountains, and return safely to their home base. DSMC licensed this exercise from Eagles Flight, a Canadian firm which specializes in developing short experiential exercises.

The next two experiential exercises were developed in conjunction with the Management Simulation Projects Group at New York University. The first exercise focuses on key issues involved in contract management and is set in a government contracting office. This exercise is used as an instructional tool in a two-week

acquisition management course for senior contracting personnel.

The second exercise, Foodcorp II, is designed to deal with executive skills in the context of operating a major food company. This exercise focuses primarily on observing management and leadership behaviors using Baldrige and Excelsior Quality Management Award Criteria as a baseline. Foodcorp is offered and as featured parts of DSMC's 14-week Advanced Program Management Course and 3-week Executive Management Course.

Looking Glass was the first behavioral exercise used by DSMC. It was developed by the Center for Creative Leadership in Greensboro, North Carolina. The commercial manufacturing scenario is not closely related to that found in Defense organizations. However, the scenario's managerial issues have considerable parallel to those faced by Defense managers. The commercial scenario also provides a "neutral playing field" for Defense managers to focus on developing their leadership and management skills (instead of concentrating on content issues in the scenario).

DSMC's newest experiential exercise, Moon Base Alpha, was taken from real U.S. National Aeronautics and Space Administration (NASA) project files. Students become program managers in an international space agency charged with developing a lunar mining base. Through a series of integrated vignettes, students are required to demonstrate key program management skills.

The Mouse Trap Car is an adaptation of the popular university engineering demonstration project. Students form contractor teams and work through the Defense acquisition process to develop prototype model cars. The exercise culminates with a competitive run-off in front of the entire student body.

Grand Slam is the most elaborate of DSMC's experiential exercises. It covers the entire life cycle of a Defense missile program with the class acting as the program office.

ASSESSMENT EXAMPLES

A key challenge in using experiential exercises in Defense acquisition career training is how to assess required student competencies. Much of the early development of experiential exercises concentrated on feedback and self-assessment of students' managerial and leadership behaviors. However, recent work at DSMC has been focused on adapting experiential exercises for more rigorous assessment of designated acquisition career competencies. The remainder of this section will highlight assessment techniques now used in DSMC's Moon Base Alpha exercise.

The Moon Base Alpha scenario puts students into seven interrelated program managers role in an international space agency (ISA) which is developing a lunar base. The ISA organization chart is illustrated in Figure 4. Moon Base Alpha consists of three sequential exercises, an initial in-basket followed by two team performance exercises. Learning objectives run the spectrum from acquisition knowledge to leadership skills as shown in Figure 5.

The in-basket exercise can be assessed in a variety of ways depending on the competencies being assessed. Leadership and management competencies can be assess using "model" in-baskets which detail expected responses for self-scoring by students. An example in-basket issue and

"model" response are illustrated in Figures 6 and 7. A more rigorous assessment of students' acquisition functional competencies is illustrated in Figure 8. After reading the in-basket materials, students respond to a number of proposed program actions in each functional area. The responses are again scored against a model as illustrated in Figure 9. In fact, responses on this type of assessment can be scored simultaneously against different types of competencies as shown in Figure 10.

Team performance exercises can also be scored using a variety of techniques. One of these, the peer rating sheet, is illustrated in Figure 11.

SUMMARY

The benefits of using experiential exercises in training are summarized in Figure 12. Student feedback has supported the premise that such exercises are powerful learning tools that can concentrate over a short period of time what can take much longer to learn whether on the job or in a more traditional classroom environment.

Currently, acquisition organizations are competing in increasingly uncertain, changing, risk-filled times. A great premium will be paid for developing top flight acquisition managers who can operate effectively in this constantly changing and highly constrained resource environment. Just as this new environment calls for acquisition managers to develop new and more effective management approaches, so too will the organizations which train these future managers need to develop new and more effective training methods exemplified by experiential exercises.

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Figure 1. CHARACTERISTICS OF EXPERIENTIAL EXERCISES

- o Realistic situation
- o Complexity of issues and opportunities
- o Multiple roles with different information and perspectives
- o Experiential learning ("learning by doing")
- o Freedom of action by students
- o Extensive feedback on student behaviors and results
- o Emphasis on reflection and self-assessment

Figure 2. COMPARISON OF EDUCATIONAL METHODOLOGIES

	Case Studies	Computer Simulations	Experiential Exercises
Materials	One case	One case with computer instructions	Individually tailored cases
Viewpoint	Students view case from same perspective (as external consultants)	Students view case from same perspective (as competitors)	Each student has a different role, information and perspective
Approach	Analyze problems and propose solutions	Students compete with each other and against computer model	Students assume roles with instructors as observers/role players
Class Session	Instructor-led seminar	Interaction with computer	Interactive experience
Results/Product	Logical analysis and acceptable solutions	Computer analysis and comparison with other students	Personal feedback on both content (what was done) and process (how it was done)
Primary	External assessment	External assessment	Self assessment

Figure 3. DSMC EXPERIENTIAL EXERCISES

Simulation	Length	Purpose
Gold of the Desert Kings	1/2 day	Goal Setting/Team Building
Contract Simulation	1 day	Contract Management
Foodcorp II	1 day	Strategic Planning/Quality Management
Looking Glass	2-3 days	Management/Executive Skills
Moon Base Alpha	2 days	Program Management
Mouse Trap Car	2 weeks	Program Management
Grand Slam	2 weeks	Program Management

Figure 4. ISA ORGANIZATION CHART

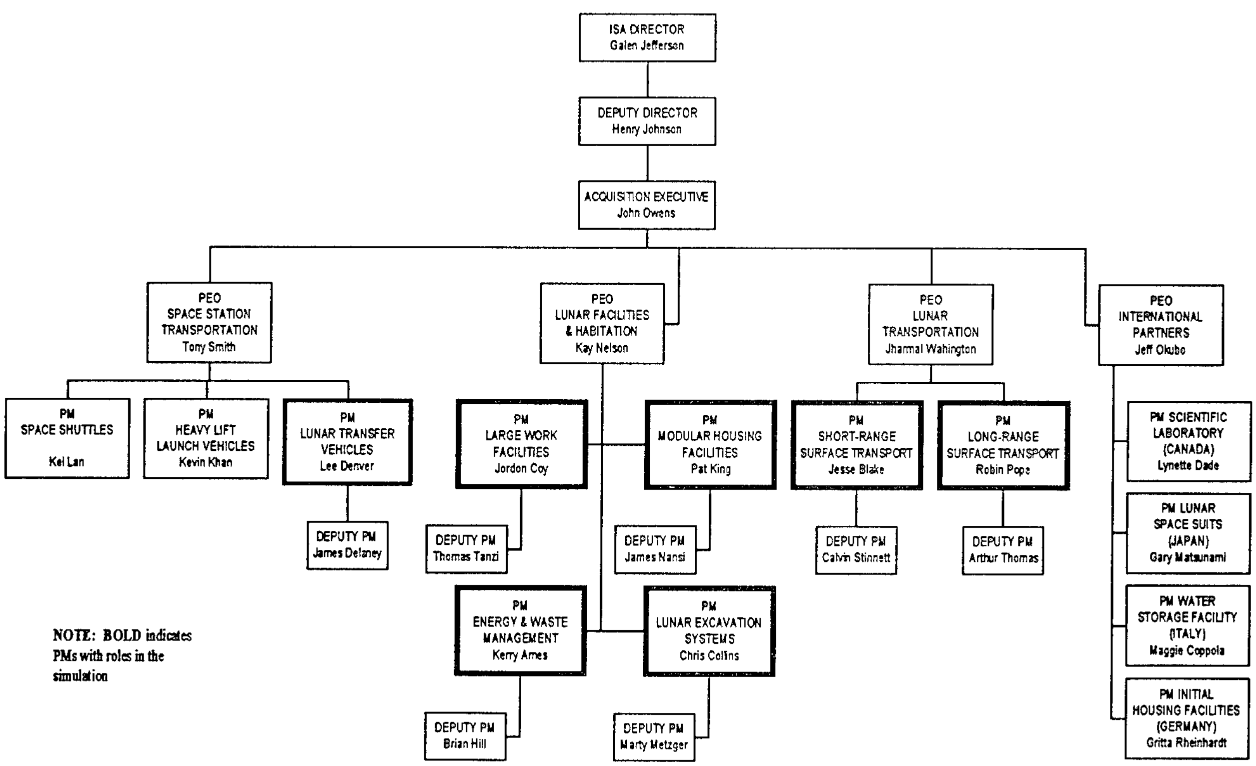

Figure 5. MOON BASE ALPHA LEARNING OBJECTIVES

• Technical Competencies

- -Acquisition Strategy
- -Test and Evaluation
- -Ensuring Design Meets Requirements
- -Cost/Schedule Performance
- -Contract Management

• Essential PM Elements

- -Cost
- -Schedule
- -Performance
- -Supportability

•Management Competencies

- -Relationship Development
- -Managerial Orientation
- -Political Awareness
- -Political Awareness
- -Strategic Influence

•Time Management Elements

- -Process
- -Perception
- -Prioritization
- -Judgment

Figure 6. MOON BASE ALPHA IN-BASKET ISSUE

ISSUE SUMMARY: A relatively small company, Glenn-Tech Inc., beat an industry giant, Prentice Industries, for the waste management system contract. Although the contract is well underway, Prentice has filed a formal retroactive complaint. The basis of their complaint is that Glenn-Tech has failed to use the key personnel or facilities which they originally proposed on the waste management system contract. It appears that Prentice carries a great deal of weight and is trying to have a Stop Work Order issued while their claim is investigated.

<u>Questions for Discussion</u>

1. Per the ISA General Counsel, the PM will be required to present a rebuttal to the formal complaint. What information will be needed (e.g., source selection process & criteria) and who and where will the rebuttal information be derived from?

2. How can Glenn-Tech's excellent performance to date be used as an argument to negate the complaint and issuance of a Stop Work Order?

3. What contingency plans are necessary in the unfortunate event that a Stop Work Order is issued?

Figure 7. MOON BASE ALPHA MODEL ISSUE RESPONSE

ISSUE: FORMAL COMPLAINT OVER THE AWARD OF THE WASTE MANAGEMENT SYSTEM CONTRACT

SUGGESTED ACTIONS:

RELATIONSHIP DEVELOPMENT (RD)

1. Contact Shaqueena Walker, General Counsel, to introduce yourself and to mention that your staff is preparing data which will document the contractual fairness o the waste management system selection process (**Actively introduce self to new personnel**).

2. Inform the PEO of the complaint (**Make superiors aware of potential problems**).

MANAGERIAL ORIENTATION (MO)

3. Task the Chief of Procurement to brief you and compile critical contract selection data (as referenced in Item 16 model responses) (**Delegate tasks to appropriate personnel**).

STRATEGIC INFLUENCE (SI)

4. Discuss this problem with the Acquisition Executive (Owens) at Friday's staff meeting (Item 26). Inquire as to which persons will make up the General Counsel. Emphasize to Owens that Glenn-Tech (current contractor) is doing an excellent job, and ask Owens for recommendations and his support on stopping the possible Stop Work Order (**Cultivate support of powerful person**).

SUMMARY OF ACTIONS TAKEN:

RD	**1**	**Perceived/Performed:______**	**Did not Perceive/Perform:______**
RD	**1**	**Perceived/Performed:______**	**Did not Perceive/Perform:______**
MO	**3**	**Perceived/Performed:______**	**Did not Perceive/Perform:______**
SI	**4**	**Perceived/Performed:______**	**Did not Perceive/Perform:______**

Figure 8. MOON BASE ALPHA DECISION RANKING ASSESSMENT EXAMPLE

Test Questions - Acquisition Strategy

Throughout the In-Basekt Exercise, there are a variety of suggestions and recommendations for performing program-related actions which support, partially deviate, or are contrary to the current Acquisition Strategy. Using the following scales, classify and rank order the appropriateness of the following Suggested Actions related to Acquisition Strategy.

Suggested Actions	Classification A = Agree D = Disagree	Ranking (1 - 10) 10 = Most Effective Action 1 = Least Effective Action
(1) Initiate an effort to obtain funding for limited demonstration of a wheeled vechicle alternative approach during Demonstration/Validation.		
(2) Revise the current cost estimation strategies proposed (IPS - Annex B) for projecting life-cycle cost (e.g. vehicle tracks).		
(3) Allocate funds to assess the use of nuclear power technology in place of the current fuel cell technology being designed and developed.		
(4) Re-evaluate the current proposed contracting strategy (e.g. number of contractors, contract type - IPS Table 2) to be employed throughout the life of the program, and make revisions or implement appropriate control procedures as necessary.		
(5) Recommend to the PEO that the Acquisition Strategy be revised to include use of Low Rate Initial Production (LRIP) as a means to correct system deficiencies early in production and deployment.		
(6) Investigate and consider eliminating the reliability-growth program, and its use of Test, Analyse, and Fix (TAAF) testing during Full Scale Development, as a means to reduce program costs and to accelerate the program schedule.		
(7) Modify current design and subsequent full-scale development philosophy to include Pre-Planned Product Improvement (P^3I) as a means to increase system flexibility and capabilities.		
(8) Modify the acquisition strategy to carry two contractors through Demonstration/Validation and to downselect to one contractor at Milestone II and entry into EMD.		
(9) Incorporate concurrent engineering approach into the development cycle. Include the requirement to concurrently build a production capability during the EMD phase so that at Milestone III, a production capability will exist.		
(10) Add trainers and simulators to development testing and training efforts.		

Figure 9. MOON BASE ALPHA EXAMPLE IN-BASKET ASSESSMENT REPORT

ACQUISITION STRATEGY STUDENT John Doe DATE: Jan 15, 1994

	Student Responses								**Student Results**			
	[Input]	[Input]			**Answer Key**				Corr=1	Rank		SUBTOTALS
	A or D	Rank			A or D	Rank			Incor=0	Difference		
SA 1	A	7		SA 1	D	6		SA 1	0	1		Possible 10
SA 2	A	9		SA 2	A	7		SA 2	1	2		Correct 6
SA 3	D	1		SA 3	D	3		SA 3	1	-2		Percent 60%
SA 4	A	10		SA 4	A	10		SA 4	1	0		
SA 5	D	2		SA 5	D	2		SA 5	1	0		Total Rank
SA 6	A	8		SA 6	D	1		SA 6	0	7		Difference 20
SA 7	D	4		SA 7	D	4		SA 7	1	0		
SA 8	A	5		SA 8	D	5		SA 8	0	0		Avg. Rank
SA 9	A	6		SA 9	A	9		SA 9	1	-3		Difference 2.00
SA 10	D	3		SA 10	A	8		SA 10	0	-5		

Figure 10. MOON BAE ALPHA MULTIPLE SCORING EXAMPLE

ANSWER KEY - ACQUISITION STRATEGY

	Classification Score	**Ranking Score**	**Management Competencies**				**Essential Program Management Elements**			
Suggested Action #	Agree (A) or Disagree (D)	Key Rank	Relationship Development	Managerial Orientation	Political Awareness	Strategic Influence	Cost	Sch.	Perf.	Spt.
(1)	D	6			••••	•	✓	✓	✓	
(2)	A	7	•••	••	••	•	✓			
(3)	D	3	••		••••	•	✓		✓	
(4)	A	10		•	•		✓			
(5)	D	2	•	••	••	•••	✓	✓		
(6)	D	1	••	•	•••	•	✓	✓		✓
(7)	D	4		•	•••	••••	✓		✓	✓
(8)	D	5			•••	•	✓	✓	✓	
(9)	A	9			••	•	✓	✓		
(10)	A	8	•	•	••	••	✓		✓	✓

Figure 11. MOON BASE ALPHA EXAMPLE PEER RATING SHEET

Ratee: PM - Large Work Facilities (LWF)

Overall Competency Rating
5 - extremely effective
4 - more than effective
3 - effective
2 - marginally effective
1 - not effective

Behavior Rating
X - strength
0 - needs improvement
N - not observed/neutral

Overall Competency Rating (1 to 5)	OPTIMIZING
	Organizes and analyzes data surrounding a problem in order to generate and evaluate alternative solutions. Makes decisions that maximize overall benefits to the program. Makes explicit choice among options based on an assessment of costs, benefits, and risks involved.
3	

X **Provides the group with an understanding of the content/utility of the information.**
- X Restates and summarizes the contents of the data verbally.
- X Responds informatively to questions about information.
- 0 Asks targeted questions to evaluate a team member's position or understanding.

X **Coordinates the team to generate alternative solutions to the problem.**
- X Helps the team to develop a plan of action based on an evaluation of the situation.
- X Helps the team to list alternative solutions for the identified problem.

X **Helps the team to identify and evaluate costs and benefits of each alternative.**
- X Helps the team to list the advantages and disadvantages associated with each alternative.
- X Helps the team to determine the critical factors to consider in evaluating alternatives.
- 0 Encourages the team to discuss all alternatives before eliminating any from consideration.
- 0 Helps the team to balance the conflicting needs of team members.

	Strongest Competency	Competency Most in Need of Improvement
Relationship Development	X	
Results Orientation		
Assertiveness		X
Optimizing		

Figure 12. BENEFITS OF EXPERIENTIAL EXERCISES

- Are inherently interesting and motivating
- Allow tailored assignments to fit student needs
- Allow students to experience the different stakeholder perspectives that affect the outcome of major program decisions and actions
- Give students a feeling (or gestalt) of what it is like to manage in a complex, realistic program management environment
- Put the focus squarely on the leadership and management skills found to be most critical to success
- Provide real-time feedback from multiple sources (self, peers and facilitators as well as comparison with prior exercises)
- Encourage transition from classroom learning to job application

ACQUISITION PLANNING AND MANAGEMENT

COMPARATIVE TRENDS IN ONGOING ACQUISITION RESEARCH

James W. Abellera
Defense Systems Management College

ABSTRACT

Previous research has shown that the aims of acquisition studies conducted within universities differ from those of acquisition studies conducted by or for the DoD. This study compares recent shifts in the distribution of broad topics for the two research communities. The results show that acquisition-research priorities for both groups changed during the 1993-94 period. Although their priorities did not converge, the communities moved in generally parallel research directions.

BACKGROUND AND THE PROBLEM.

In 1989 the Defense Systems Management College started a research program called "Research on Ongoing Acquisition Research (ROAR)" to discover the types and extent of **ongoing** defense-related acquisition policy studies **[1]** conducted by professionals inside and outside the DoD. The purpose of ROAR was to create an information system to satisfy two objectives.

The first objective was to enable acquisition researchers to access ROAR information freely and discover other researchers who were working on similar acquisition issues. This would help them to accelerate their studies through mutually benefical exchanges of empirical data and experiences.

Second, DoD policymakers could use ROAR information to review ongoing acquisition studies on topics of immediate policy interest. Thus they might avert spending money for new research starts that would duplicate work already in progress. Or policymakers might quickly obtain useful findings from projects that were nearing completion but were not yet published or otherwise identifiable through a search of existing databases, such as the Defense Technical Information Center (DTIC), Defense Logistics Studies Information Exchange (DLSIE), Compuserve, and traditional library indexes.

As the program began, ROAR researchers agreed that the program would capture abstracts of ongoing research from all major professional sources. It was also understood that the DoD finances the production of thousands of reports related to acquisition policy each year. The research underlying the reports is conducted by the DoD's own employees, by the employees of its Federally Funded Research and Development Centers (FFRDCs), and by for-profit contractors. **[2]**

Centralized DoD bibliographic sources (used by DoD researchers and policymakers to discover published and ongoing studies in defense acquisition policy) gave ample, albeit incomplete, evidence of research performed within and funded by the DoD. Within-DoD research is defined here to include studies performed by the DoD's employees, for-profit contractors, and FFRDCs. The same centralized sources offered little evidence

that research was performed outside the Defense Department -- by professors and fellows in universities for example. [3]

However, an informal review at that time of articles in well-known professional journals for selected disciplines (e.g., engineering management, economics, law, political science, operations research, finance, business management, etc.) suggested that university scholars were conducting defense-related acquisition policy studies as well.

To ensure ROAR's coverage of acquisition studies would not overlook any major source of such research, the program gathered information about ongoing research projects at universities and other outside-DoD organizations (e.g., non-profits without affiliation with the DoD and trade associations) as vigorously as it collected information on within-DoD efforts.

Abstract data collected by ROAR from 1989 to 1992 showed that 42% (370 of 876) of ongoing acquisition studies were conducted within universities. Also, a study of funding sources for the 370 university-based research revealed that the Defense Department financed only 5% of such studies. The remaining 95% of university projects were funded primarily by the universities themselves. Private foundations and corporations also furnished support. [4]

The 1989-92 data revealed that university projects differed from within-DoD studies in the distribution of broad acquisition topics each community studied. Compared to within-DoD projects, the university studies were skewed toward issues concerning Commercial Products & Practices, Defense Acquisition & the Political Process, Engineering & Manufacturing Matters, International Acquisition Issues, and the Industrial Base.

Compared with within-DoD projects, the university work was skewed away from issues concerning Cost & Price Considerations, Decision & Data Support, Financial Management, Streamlining Acquisition Management. [5]

HYPOTHESIS

It was expected that the priorities of both the within-DoD and the university research communities would shift with the passage of time. One theory about the direction of changes, which could be explored in the distribution of topics for ongoing studies captured by ROAR after 1992, was that each community would move roughly in tandem with the other. That is, a sharp change in one community's emphasis toward or away from one major topical area -- relative to the pattern of 1989-92 -- would also occur in the same direction for the other community.

The rationale for tandem distributional changes over time is that researchers in both communities attempt to formulate studies that are responsive to current issues and problems facing acquisition policymakers. While their funding sources and backgrounds may be different, both types of researchers want their studies to answer existing or foreseeable public-policy needs.

Such needs are transmitted in new federal programs, in national policy statements by the President and other leaders in the executive branch, and by pronouncements from members of congress and from industry leaders.

Of course, no relationship may exist between priority shifts of each community. In this case one expects to see a roughly even, and therefore random, mix of tandem and non-tandem trends.

In this study, ROAR abstract data collected from 1993 through 1994 are analyzed and compared with similar data for the 1989-92 period to determine if within-DoD and university researchers generally changed their research priorities in tandem.

To simplify tandem analysis, the analysis focuses on topical areas showing shifts greater than five percentage points relative to the 1989-92 baseline.

FINDINGS AND DISCUSSION

Table 1. below shows percentage distributions by broad research topic for the within-DoD and university research communities ***combined***, for the 1989-92 period and for the 1993-94 period. The latter period includes 1,332 studies that were captured by the ROAR program after 31 December 1992. Data for the former period were presented in a 1993 study as simple frequency distributions. **[6]**

Topical areas that show shifts greater than five percentage points across the two periods are underlined.

In the 1993-94 sample, 42% of the 1,332 newly-captured ongoing studies were conducted by university researchers.

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Table 1. Topical Area-Shifts in ROAR Studies Across Periods

Topical Area	Incidence 89-92 (n=876)	Incidence 93-94 (n=1332)	Difference
Commercial Products & Practices	13%	38%	25%
Engineering & Manufacturing Matters	14%	26%	12%
Contracting & Subcontracting Issues	24%	34%	10%
Industrial Base	22%	33%	10%
Cost & Price Considerations	21%	27%	6%
Streamlining Acquisition Mgmt	16%	17%	1%
Defense Acquisition & the Political Process	12%	12%	0%
Acquisition Management Education & Workforce	18%	18%	0%
International Acquisition Issues	10%	9%	-1%
Financial Management	10%	8%	-2%
Logistics Issues	26%	22%	-4%
Decision & Data Support	31%	20%	-11%

Percentages displayed in each of the first two columns of numbers do not sum to 100% because most studies were classified as belonging to at least two topical areas simultaneously. Some studies were assigned to three or even four topical areas because of the nature of the specific research.

Six topical areas underlined in Table 1. indicate shifts exceeding five percentage points across the periods.

Data for six groups is further disaggregated below, in Table 2., to show shifts that occurred for the within-DoD and the university communities across the two periods.

Table 2. Comparative Topical-Area Shifts by Communities

Topical Area	Within-DoD Community (W) 89-92	Within-DoD Community (W) 93-94	University Community (U) 89-92	University Community (U) 93-94	Period-Shift Differences (W)	Period-Shift Differences (U)
Commercial Products & Practices	10%	22%	16%	62%	12%	46%
Engineering & Manufacturing Matters	12%	21%	18%	34%	9%	16%
Contracting & Subcontracting Issues	24%	46%	25%	19%	22%	-6%
Industrial Base	21%	30%	25%	36%	9%	11%
Cost & Price Considerations	25%	31%	16%	22%	6%	6%
Decision & Data Support	39%	25%	19%	13%	-14%	-6%

Table 2. data confirm that, for five of the six topical areas in which sharp shifts occurred in the incidence of ongoing studies, the trends occurred in tandem (in the same direction) between the within-DoD and the university research communities. However, the small number of data points does not make statistical testing useful for rejecting or accepting the counter view that the observed outcomes are simply random occurrences.

With regard to convergence, inspection of the frequency distributions for the two communities indicates that they were not congruent in 1989-92, nor did they become so in 1993-94.

While evaluation of all of the comparative sub-trends suggested by the data is beyond the scope of the present study, the single instance of non-tandem trends, in the Contracting & Subcontracting Issues area, warrants a word of discussion.

The recent high DoD priority of reforming the acquisition process may explain why the incidence of contracting-related studies for the within-DoD community jumped 22 percentage points from 1989-92 to 1993-94.

During the later period, however, defense contracting's specialized nature may have made useful studies difficult for university-based researchers, because thousands of rules were subject to substantial and sudden changes. Thus, the small decline in incidence for universities of six percentage points could reflect the relative disadvantage perceived by college researchers in making valuable contributions during a time of rapid internal DoD changes to these complex rules.

CONCLUSIONS

Analysis of ROAR abstract data spanning six years does not disconfirm the theory that both the within-DoD and the university communities of acquisition researchers shifted their study priorities in tandem. One of six areas in which sharp shifts occurred offers contrary evidence.

There is no evidence in the presented data that the acquisition-research priorities of the two communities converged after 1992, nor is there evidence that convergence is more or less likely than other possible outcomes in future years.

It does appear that university researchers responded in 1993-94 to emerging acquisition issues in roughly the same way as their within-DoD counterparts. The evidence is not strong however. Whether tandem shifts in priorities continue will depend partly on how well each community tries to meet the demand for effective public policies with timely acquisition-related research products.

FOOTNOTES

1. Defense acquisition policies delineate between acceptable and unacceptable management practices for controlling how the DoD acquires goods and services. Defense acquisition policy research is defined here as research that improves understanding about effective practices at various levels of control and also about internal and external circumstances that can cause the DoD to change its policies. Some policies describe practices that are unique to DoD. Others deal with practices that are commonly used in less-tightly regulated organizations such as companies and non-DoD government agencies.

2. Part of the annual publications output is reported in Defense Logistics Studies Information Exchange, 1993 Annual Department of Defense Bibliography of Logistics Studies and Related Documents, Department of Defense, 1993, pp. 1-663. The volume lists over 1400 titles produced by or for DoD each year. Although less than half of the logistics-related reports listed are considered by the author to involve acquisition policy research, logistics concerns form only one of many areas germane to acquisition policy.

3. Ibid., pp. 664-661. For example, 23 logistics-related projects were performed by universities out of 2,805 total projects completed and published with DoD funding during a two-year period. Also, the IDA (Institute for Defense Analyses) Cost Research Symposium began an innovative program in the early 1980s to identify and disseminate news about ongoing research on cost-estimating models and other cost issues in DoD acquisition. In 1989 IDA reported 209 projects to the Symposium's within-DoD participants. No university research was included; all reported projects in 1989 were performed by within-DoD organizations. See S.J. Balut and K.L. Wilson, "The IDA Cost Research Symposium," Institute for Defense Analyses, IDA Document D-647, August 1989, various pages.

4. Abellera, J. W., "National Resources for Defense Research," Proceedings, 1993 Acquisition Research Symposium, Defense Systems Management College and the Washington, DC Chapter National Contract Management Assoc., pp. 3-4.

5. Ibid., pp. 5-7.

6. Ibid.

REDESIGNING THE DEFENSE ACQUISITION PROCESS

by
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ABSTRACT

Over a period of six years, the Technical Managers' Advanced Workshops (TMAW) studied the Defense acquisition process. The first workshops sought to define what Program Managers did and the kinds of things that affected their work. The second set of workshops was sponsored by the then incumbent Under Secretaries of Defense (Acquisition) to examine in detail the problems experienced by Program Managers which caused program execution to differ from program plan. Other workshops sponsored or requested by Program Offices, the Defense Inspector General's Office (DoDIG), the Defense Intelligence Agency (DIA) and the Office of the Secretary of Defense (OSD) examined specific kinds of difficulties experienced within the acquisition process. Finally, another series of workshops determined the functions performed in creating effective, supportable weapon systems and defined an acquisition process around those functions. That accomplished, a workshop was held to see if implementing the newly designed functional process would alleviate the difficulties previously experienced with the Defense Acquisition System (DAS).

This paper provides a broad overview of that work.

THE WORKSHOPS THAT PROVIDED ACQUISITION DESIGN KNOWLEDGE

Twenty eight workshops were held during a 39 month period. Table 1 provides: (1) the dates of the workshops; (2) workshop sponsor; (3) general area of investigation, and (4) where applicable, the focus questions posed to workshop participants. The workshop results and the methodology used to achieve those results were reported in DSMC publications entitled, "Technical Managers' Advanced Workshop (TMAW) Reports". TMAW reports were not widely distributed. Much information was elicited under DSMC's "***Non-Attribution***" rule and the sources of the data are protected. For workshops sponsored directly by the Under Secretary of Defense (Acquisition) USD(A) or by the Director of Defense Research and Engineering (DDR&E), special reports were issued under their imprimatur and distributed by their office. In the case of Concurrent Engineering workshops, a report and annexes were widely distributed throughout the DoD, the individual Services, and the defense industrial base. During the past three years, concurrent engineering has become institutionalized throughout the defense community as Integrated Product Development (IPD) and Integrated Product and Production Teams (IPPT).

Each workshop consisted of between eight and 14 participants drawn from all of the stakeholder organizations. Participants represented a full spectrum of perceptions and perspectives of most individuals involved with the DAS. In all, over 300 individuals, each selected by their Commands because of specific knowledge of the workshop subject matter, contributed to the redesign process.

Table 1
TMAW WORKSHOPS

WORKSHOP GROUPS AND DATES	WORKSHOP SUBJECT MATTER
Group 1 DSMC Sponsored	
06/15 - 06/19 1988	"What Do Technical Managers Do?"
11/30 - 12/04 1988	"What Forces Cause Change?"
05/26 - 05/30 1989	"How should Technical Managers Handle Change?"
Group 2 USD(A) Sponsored	"Why Do Smart Munitions Cost More and Why Are They Late?
08/11 through 10/13 1989	
08/11 to 10/13	Air to Surface Programs
09/12 to 09/13	Surface to Surface Programs
09/19 to 09/21	Surface to Air Programs and ASW Programs
10/11 to 10/13	Air to Air Programs and ASW Programs
12/04 through 12/08 1989	"Suppose Smart Munitions Changes Were Made?"
Group 3 DoDIG Sponsored	
10/02 to 10/04 1989	"Performing the Test & Evaluation Inspection"
11/27 to 11/29 1989	"Should HARPOON Become Multi-Source?"
Group 4 USD(A) Sponsored	
03/14 to 03/15 1990	"Define and Discuss Program Stability"
07/17 to 07/19 1990	"What Problems Are There In Reducing Risk"
11/06 to 11/07 1990	"Problems of Aligning Requirements and Resources
11/26 to 11/27 1990	"Why are Firms Leaving the Industrial Base?"
11/29 to 11/30 1990	"What Are The Problems With Program Oversight?"
12/11 to 12/12 1990	"How to Improve The Industrial Base> "
08/19 to 08/21 1991	"The Future Role Of The Industrial Base"
Group 5 OSD Elements Sponsored	
02/12 to 02/14 1989	"System Engineering Round-Table" DSMC
06/25 to 06/29 1990	"Problems With Implementing CALS" OSD CALS
12/17 to 12/21 1990	"Implementing Concurrent Engineering" OSD
01/22 to 01/26 1991	"Developing CITIS" DDR&E, CALS
01/28 to 01/29 1991	"Concurrent Engineering Planning Session" OSD
02/27 to 03/02 1991	"Joint U.S. Canada Technology Integration" ASD(PR)
05/22 to 05/24 1991	"Which Technology Should Be Integrated?" ASD(PR)
08/28 to 08/30 1991	"Contractor Integrated Technical Information" OSD
Group 6 DSMC Sponsored	
06/21 to 06/25 1991	"Integrating An Acquisition Process Data Base"
07/23 to 07/24 1991	"Integrating An Acquisition Process Data Base"

WHAT THE WORK SHOPS REVEALED

The first group of workshops examined the functions performed by Defense Program and Technical Managers. Workshop participants described the function in general terms and when asked what problems they had in carrying out their responsibilities, responded by stating their frustration with the lack of program stability, and their own inability to satisfy the need to remain flexible; specifically, to waive use of inappropriate specifications and regulations when that was necessary to maintain program integrity.

The second group of workshops was held for the USD(A) who invited all major smart munitions program managers and their

contractor counterparts to participate. The workshop recommendations focused on change to the acquisition management structure in order to give program managers authority commensurate with their responsibilities. The last workshop in this series prepared recommended changes for USD(A) implementation. While considering those recommendations, it became clear that a methodology which could predict how the DAS would respond to proposed change was lacking. Unfortunately, the workshop held to discuss that subject could not find a more rigorous approach than what had been employed in the past.

The third group of workshops explored the DoD Inspector General role in two specific instances: (1) How the DoDIG might best structure an inspection into DoD Test and Evaluation procedures; and (2) When it would be appropriate to change acquisition strategy from prime contractor to "break-out" of major portions of the system for direct Program Office management. Participants described difficulties in holding to promised schedule and performance objectives when financial and methodological reviews were initiated for established on-going programs.

The fourth group of workshops was directed by USD(A) to assist in developing improvement to the DAS. The participants were selected by USD(A) and were asked to consider all of the problems they had experienced with a view toward generating actions USD(A) could take to help prevent those problems from recurring. The workshops reinforced the need, stated in the first three workshops, for flexibility in dealing with change. In fact, workshop participants described program stability as, "the ability to deal with change in a timely manner". Participants also found that a great deal of risk could be introduced by resource uncertainties, and that the difficulty in properly aligning resources with program requirements was due to inflexibility of the DAS process; and that some firms were leaving the defense industrial base because of the imposition of oversight requirements unnecessary and harmful to the conduct of normal business activities.

The fifth group of workshops dealt with technology integration and change in program management methodologies made possible through improved technical equipment and concepts. Focus was on the search for ways to encourage progress toward a paperless society, and with integration of various skills within program offices to achieve integrated, multi-skilled teams of individuals which could better assure smooth transition from ideas to fully supported weapon systems. One major insight resulted: it was shown that while some industrial organizations had been able successfully to integrate required skills into teams and had established integrated, paperless data bases, the requirement of government oversight had inhibiting effects on achieving those goals.

Examination of the possibilities of integrating U.S. and Canadian technical activities revealed that although considerable integration could be accomplished specifically in material development research, there were difficulties in arriving at joint activities within then current DAS constraints.

The sixth group of workshops undertook to integrate all of the DAS problems discussed during the preceding workshops (678 problems were discussed) and structure them to better enable proposed actions aimed at eliminating or alleviating them. In a sense these workshops were tasked to provide the road map for defining potential change. The

resulting work appears in Table 2 where 20 broad problem areas are defined.

Table 2

PROBLEM CATEGORIES WITHIN THE ACQUISITION PROCESS

PROBLEM	PROBLEM CONTEXT AND DEFINITION
PROGRAM MANAGER AUTHORITY **D**	The authority of the program manager is severely undermined by the cumulative effect of a variety of intrusions into program management. In their totality these intrusions introduce major confusion into ongoing activity, and damage incentives to do careful planning for effective program management, increase costs, and delay schedules. Program effectiveness and efficiency are both casualties.
CONTRACT REQUIREMENTS DEVELOPMENT **F**	Contractual requirements are intended to specify the working relationships between government and contractor and to describe the end product. At present too many constraints impact ability to deal properly with data and standards. One consequence is the inability of the program manager to reward good performance and penalize poor performance.
DAB-DRB PROCESS **B**	DAB/DRB processes do not reflect an encompassing treatment across programs, with thoughtful priority setting. Moreover the processes do not adequately promote the gathering of relevant information from the acquisition community that should pertain to DAB /DRB decisions. DAB and DRB are often in conflict, not taking time to resolve differences. Failure to correct this situation leads to major and undesired budget surprises for those who inherit the impact of poorly thought out past decisions.
TECHNICAL REQUIREMENTS MANAGEMENT **D**	An overly myopic interpretation of technical requirements mistakenly assumes that they can be rigorously specified at program inception and need never be changed. The unduly restrictive interpretation placed on "requirements" and the ensuing difficulty in modifying them as new knowledge becomes relevant, over-constrains program management and is a significant source of excess time and costs. Effective program management demands that program managers have an approved and well-paved pathway to change requirements as conditions warrant.
FUNDING INSTABILITY **B**	The effect of current program funding practices is capricious and destructive of responsible management practices. The acquisition budgeting system is not conducive to effective program management, leading to enormous waste and dissatisfaction.
STATUTORY/REGULATORY INFLUENCES **B**	Statutory/regulatory influences are often unnecessarily burdensome and do not reflect what has been learned from decades of DoD program management.

Table 2 (Continued)
PROBLEM CATEGORIES WITHIN THE ACQUISITION PROCESS

PROBLEM	PROBLEM CONTEXT AND DEFINITION
COST & SCHEDULE ESTIMATES **F**	Cost and schedule estimates which have high leverage in terms of program effectiveness and manageability are seldom realistic. The current management style inevitably forces bad information into the system where it infiltrates like a virus and is a prime source of program sickness.
INTERNATIONAL FACTORS **C**	Current regulations and plans involving international military transactions furnish inadequate guidance for effective management of international transactions.
LONG RANGE PLANNING **B**	An overhaul of the long-range planning system is needed to improve investment decisions and to reflect integrated program tradeoffs.
USER SUPPORT **B**	Failure of users to sustain strong, consistent, long-term support for programs in situations where need for program products has been clearly established leads to major disruptions, confusion, and waste. Program initiation does not reflect consideration of system priorities in relation to all other existing or prospective programs. Long-term plans are not connected to short-term decision making.
INADEQUACY OF PROGRAM TEAM **D**	An effective acquisition program team supports matching of demand (which involves a whole portfolio of task imperatives that grow unpredictably) with a portfolio of personnel who can respond capably. Steady increase in demand in an eroding resource environment, accompanied by high personnel rotation; inadequate personnel experience and training; and difficulties in organizing and sustaining the program team erodes program quality.
EXECUTIVE DECISION AND POLICY MAKERS **B**	High personnel turnover among executive decision makers and policy makers causes policy to change frequently. Also the turnover is responsible for (a) continuing misunderstanding of the acquisition system due to lack of program management training, experience, and skill at top DoD and services management level; (b) discontinuities and low quality of oversight, and (c) inability to provide consistent rationale to program personnel leading to de-motivation.
RISK MANAGEMENT D	Inadequate contingency planning to manage cost, performance, and schedule. There is no uniform methodology either to define or to handle risk.
INDUSTRIAL BASE **E**	The nation is losing its defense industrial base because it lacks a consistent, rational, realistic approach to industry. In the absence of articulated policy, de facto policy operates in an undesirable way.
CREDIBILITY **D**	No total quality philosophy operates to govern program oversight. Inadequate communication flows through the system, promoting lack of trust throughout.
OVERSIGHT **D & F**	As presently practiced, program oversight is ill-conceived, disorganized, and replete with role conflicts.
TRANSITION MANAGEMENT **F**	Effective system design and development requires phasing, which implies a need for smooth phase-to-phase transitions. Present practice involves inadequate phase definition, insufficient emphasis on transition management, and poorly managed transitions from one phase to another.

Table 2 (Concluded)

PROBLEM CATEGORIES WITHIN THE ACQUISITION PROCESS

PROBLEM	PROBLEM CONTEXT AND DEFINITION
TEST AND EVALUATION **A**	Current government philosophy and implementation of test and evaluation inadequately reflects good management practice. Test and evaluation practice is inconsistent with overall program objectives.
IMMUTABLE **B**	Detached, capricious, and uncontrollable high-level acquisition decision processes are responsible for micro-interference in programs. Such intrusions translate into deterioration of program quality, morale, and performance.
PROGRAM EXECUTION **F**	Current constraints on program execution favor rigidity when and where flexibility is needed; and they promote flexibility when and where rigidity is beneficial; thereby frustrating good management practices. Structural impediments, noted for their frequency and variety, make program execution inefficient, and make it very difficult for the program manager to do his job.

Table 2 was analyzed to see if broader, more generic problem categories could be inferred. The group developed the six generic problem sets shown in Table 3 below. Membership of a problem area within one of these six groups is indicated by the letter next to the problem area title in Table 2.

Table 3

GENERIC PROBLEMS AND PROBLEM CATEGORIES

GENERIC PROBLEMS	PROBLEM CATEGORIES INCLUDED
A. Test and Evaluation (1 Problem area)	Test and Evaluation
B. High Level Planning and Management (7 Problem areas)	DAB-DRB Process; Funding Instability; Statutory/Regulatory Influences; Long Range Planning; Executive Decision And Policy Makers; Immutable
C. International Cooperation (1 Problem area)	International Factors
D. Program Office Effectiveness (6 Problem areas)	Program Manager Authority; Technical Requirements Management; Inadequacy of Program Team; Risk Management; Credibility; Oversight
E. Industrial Base (1 problem area)	Industrial Base
F. Program Execution Effectiveness (5 Problem areas)	Contract Requirements Development; Cost and Schedule Estimates; Oversight; Transition Management; Program Execution

The third step was to examine the 6 broad problem areas and determine whether any of them negatively influenced any others. Figure 1 shows the structure of the problem categories and the relationships between them.

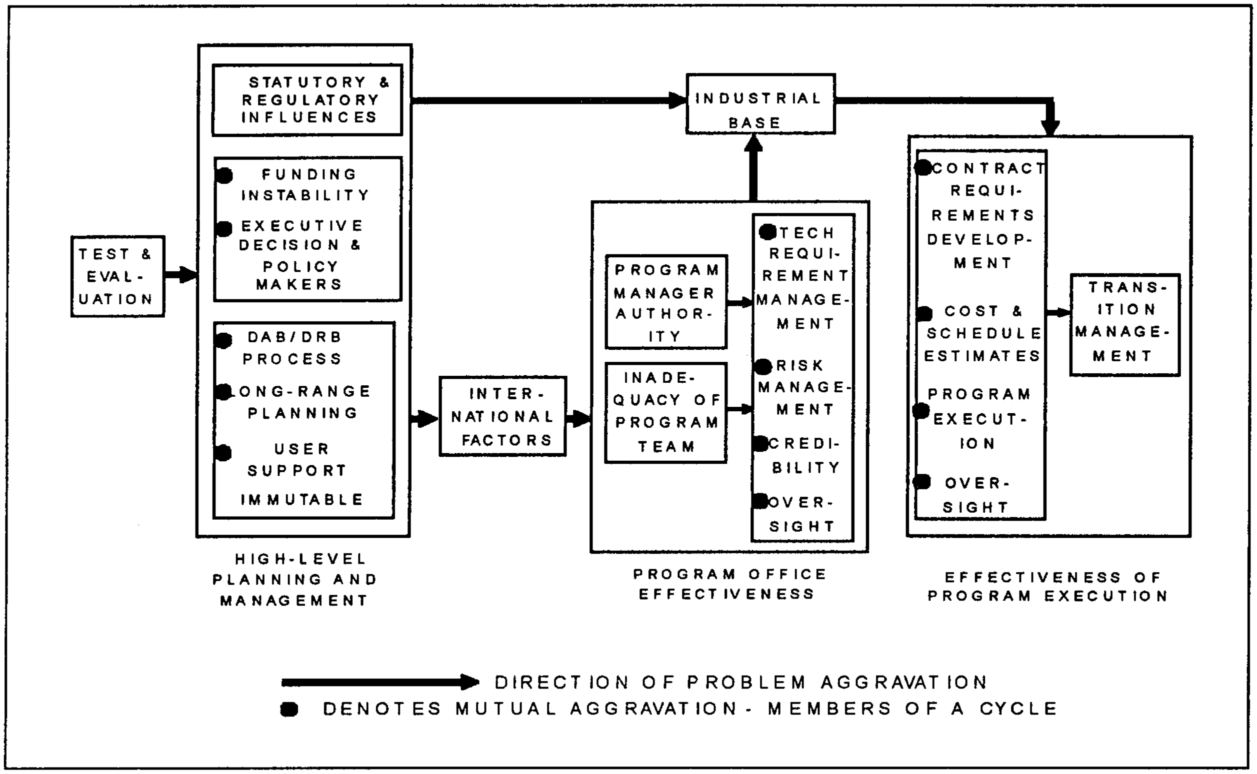

Figure 1

RELATIONSHIP BETWEEN ACQUISITION PROBLEM GROUPS AND SUB-GROUPS

In Figure 1, problems aggravate all problems which lie to their right. Test and Evaluation problems aggravate all other problems; High Level Planning and Management Problems aggravate International Cooperation and the Industrial Base; International Cooperation aggravates Program Office Effectiveness; and Industrial Base Problems aggravate Effectiveness of Program Execution.

In the sense that these major problem groupings (each containing one or more broad general problem area, and including numbers of individual problem statements) were found to be the most fundamental high level problem areas, they represent the aggregation of workshop wisdom concerning problem aggravation.

A FUNCTIONALLY DERIVED ACQUISITION PROCESS

Suppose one started with a blank sheet of paper. Could a very efficient acquisition process be defined which would permit the performance of functions necessary to take ideas and turn them into supported systems? Suppose that acquisition process consisted only of activities necessary to the main objective, what would it look like?

To answer those questions, we convened a series of five workshops. The question asked was: "What functions must be

performed to turn ideas into fully supported, fielded weapon systems?" Workshop participants were drawn from Industry, from the major Service Commands, and from OSD staff.

At the time, the Deputy Secretary of Defense had made a change from prior policy for new weapon system development. The new policy would stage development - a prototype system would be developed, and after test of that prototype, it would be decided if production quantities would be ordered. If it was decided not to produce the item, the prototype would continue to be used and data gathered about its performance and capabilities. If at some later date, production quantities were required, they would be procured using the material already in the archives that enabled production of the prototype. The workshops took the new policy as given, and defined a functional acquisition process in two parts: (1) Functions required to move from ideas to prototypes; and (2) Functions required to move from prototypes to fully supported, fielded systems.

Participants had a clear set of goals: they wanted to arrive at a process which would:

- o Replace Micro-Management with Macro-Management at all levels;
- o Replace the current "unstable, inflexible, fault intolerant" system to a stable and flexible system;
- o Move from a system which impedes telling the truth to one which promotes ethical management;
- o Recognize the fractionation and sub-optimization implicit in the present process and devise a system which permits synergy between system elements and links systems to strategy; and
- o Recognize that change in Defense budget share from 6% of GNP to 3% of GNP will make it necessary to achieve high technology at much reduced cost.

Participants were asked to:

1. Define the functions involved,
2. Group appropriate functions together,
3. Develop relationships between functional groups,
4. Define attributes of organizations focused on efficient performance of the system functions,
5. Devise relationships between organizational elements within the acquisition process and other Governmental and industrial organizations (and organizational elements) which interact with them.

MOVING FROM IDEAS TO PROTOTYPES

The acquisition process functions they believed necessary for this portion of the complete system development process contained 108 individual functions grouped within 7 general functional categories. The functional categories and the sequence of performance of functions are shown in Figure 2.

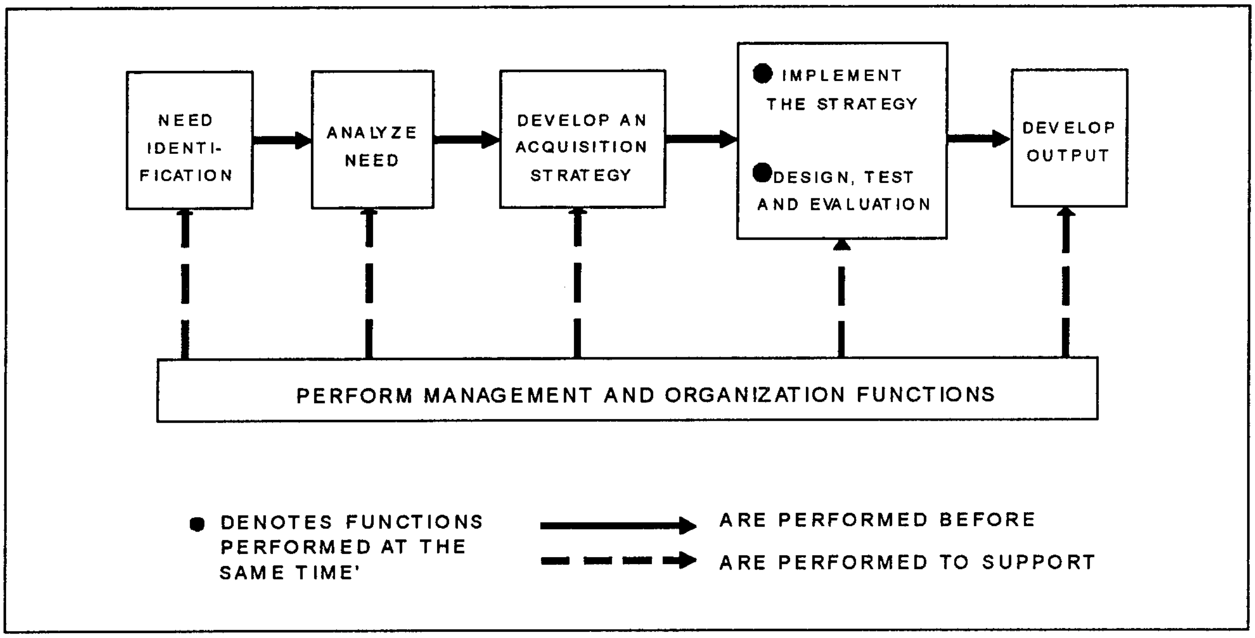

Figure 2

Figure 2 shows that Need Identification Functions must be completed prior to Analyzing Needs. An Acquisition Strategy can be developed only after needs have been developed and analyzed. Then, the strategy can be implemented concomitantly with design, test and evaluations functions. When those have been completed, the output can be achieved. Figure 2 indicates that management and organization functions are performed continuously throughout the process of taking ideas to prototype equipment.

Participants believed that Identification of Need and Analysis of Need required different kinds of skills than did the remainder of the functional process (see below).

MOVING FROM PROTOTYPES TO SUPPORTED OPERATIONAL SYSTEMS

We used the same process previously used to derive functions required to move from ideas to prototype systems. During the course of the workshop, participants developed a total of 312 statements they felt were "functions to be performed" in the process of moving from prototype weapon systems to fully supported, deployed weapon systems. Participants were asked to group all functions into a set of over-arching functional groups. Four major, temporally related, functional action groupings resulted from this activity. Figure 3 indicates the groups and the way they relate to each other. Figure 3 indicates that pre-production activities must be completed prior to entering into the production phase, and that deployment and sustaining functions follow after production functions have been accomplished.

SKILLS REQUIRED TO PERFORM THE FUNCTIONS

Participants analyzed the kinds of personnel skills required to perform the functions they defined, deciding on 7 skill sets which would cover all functions involved. The skill sets and a brief definition of what those skill sets entail is shown in Table 4 on the next page.

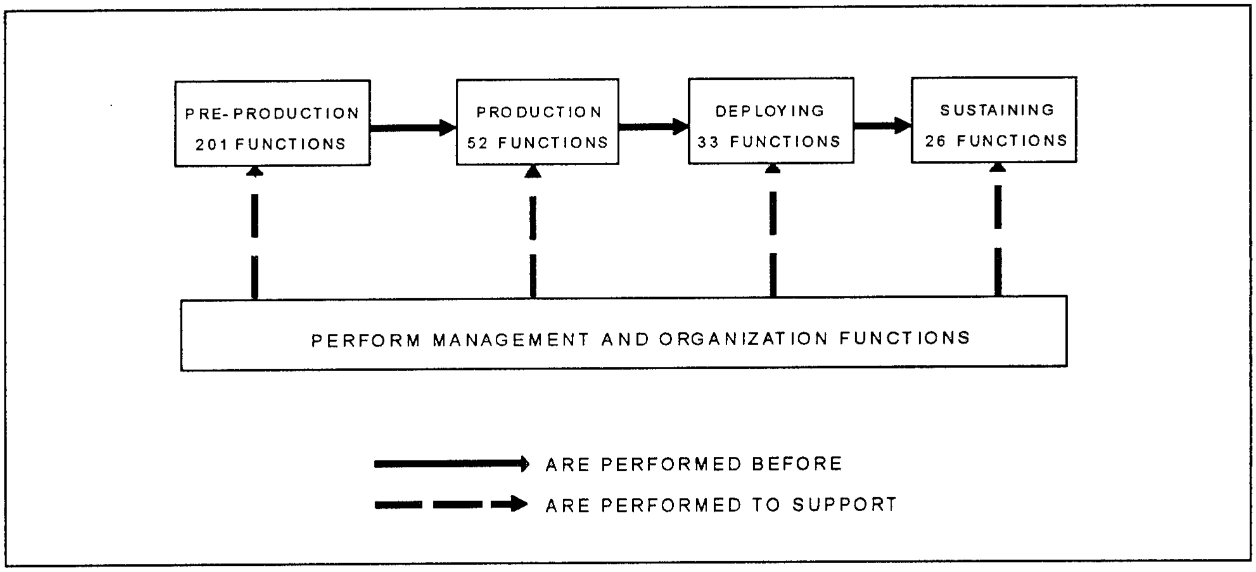

Figure 3

FUNCTIONS NECESSARY TO PROGRESS FROM PROTOTYPES TO FULLY SUPPORTED SYSTEMS

Participants used the skill set definitions to determine skill set mixes required to perform the functions within the defined acquisition process. That analysis provided insights into how best to construct a functionally responsive organizational structure for moving from prototypes to fully supported systems.

Table 4

SKILLS REQUIRED FOR THE FUNCTIONAL ACQUISITION PROCESS

SKILL SET	NARRATIVE DESCRIPTION
Management Skill Set	Primarily skilled in managing diverse disciplines; capable of understanding details of significant factors in those disciplines integral to the program.
Engineering Skill Set	Highly expert in engineering disciplines; understands principles of other disciplines integral to development, production, and sustaining activities.
Logistic Skill Set	Highly skilled and having in-depth knowledge of the principles and practices of sustainment activity at both tactical locations, and in production and program management sites.
Procurement Skill Set	Procurement professional with detailed understanding of contracting principles and practices; capable of using technical inputs from other program skill sets to achieve procurement objectives.

Finance Skill Set	Deep understanding and knowledge of financial activities and capacity to use technical inputs from other program skills to achieve timely financial support for program activities.
Manufacturing Skill Set	Expert in technology and practice of manufacture both of singular items and production quantities of complex technical sub-systems and systems Capable of defining requirements for production facilities and individual production components for both "in-use" and "new" production techniques
User Skill Set	Seasoned, skilled in theory and practice of military tactical operations. Capable of translating tactical understanding into useful input for program office team specialists to help define policies and actions which keep the program focused on its military objectives.

The skills analysis revealed the need for application of multiple skills to perform almost all of the functions necessary to move from ideas to fielded, supported systems. In fact, the analysis indicated specific kinds of multi-functional groups discussed in the concurrent engineering workshops, system engineering round tables, and other workshops in the fifth workshop group enumerated in Table 1 above. There was however, a considerable difference in the numbers of each kind of skill set required at different times during the process of moving from ideas to deployed systems.

ORGANIZING TO REALIZE FUNCTIONAL ACQUISITION

Participants became convinced that there were three major process components:

1. Defining requirements and maintaining their currency;
2. Responding to the requirements by producing, testing, and deriving an envelope of operational integrity for a prototypical system; and
3. Producing, deploying and sustaining operational systems derived from the well understood prototype.

Participants believed each process component needed its own kind of organizational philosophy.

o ***The first set of functions is dominated by user skills.*** The analysis indicates that they should be performed by highly skilled technical and military operational staff members who would review technology and operational needs, and when action was indicated, would recommend that a new weapon capability be developed. Participants believed that such work would be best performed under the auspices of the Joint Chiefs of Staff. Performance of these functions would result in a defined requirement emerging from an on-going analytical process within JCS. The JCS analysis would be formally stated, once coordinated with appropriate operational commands. The service development activities would respond to the requirement with formal development proposals.

With the proposals received, JCS and the service materiel developer would recommend issuance of a directive to develop the new weapon capability as set forth in the development proposal. The directive would be issued by an oversight group who would review both the need and the response to insure that the planned development would meet national priorities and would be of reasonable cost. The issuance of the formal directive would establish a program office and authorize that office to produce the prototype system in response to the requirements defined.

o ***The second set of functions is dominated by engineering and manufacturing skills.*** Participants felt industrial organizations provided models for performing these functions. Examples were the Lockheed "Skunk Works" which had produced the RB-70 and the U-2, McDonnell-Douglas's "Phantom Works" which had pioneered use of soft tooling for aircraft structural builds, and Burt Rutan's "Scaled Composites" organization which had produced the Voyager and other experimental aircraft. Participants believed that an autonomous, fully responsible program manager and a program management staff could efficiently and effectively perform the Government's direction and Industrial oversight functions. Numerous examples were cited as organizational and staff functional models for performing the functions within this portion of the redesigned process.

At the point when a prototype system has been developed, and sufficiently tested to have provided an envelope of operational capability, a second directive would be issued containing one of two options: (1) Continue to use the prototype system and refine it as indicated through that use; or (2) Proceed to produce, deploy and sustain some numbers of the existing system. The factors which would drive the choice were: evaluation of the prototype system against up-dated requirements, and the estimated cost and schedule involved in the production process. Given either choice, the Program Office would take appropriate action to reform itself as required. The appropriate oversight authority would be convened to issue the directive.

o ***The third set of functions is dominated by management, engineering and manufacturing skills.*** Participants once again stated that there were models within both industry and Government to serve as guides in organizing and contracting for performance of the necessary functions involved in proceeding from operating prototypical systems to fully supported deployed weapons.

When production items have been deployed and sustained under operational conditions for a time sufficiently long to judge their effectiveness and operating economies, an additional oversight point arises. The Program Office would again request convening of the oversight authority to evaluate the Field Commander's assessments of the system, and the assessment of the permanent requirements organization within the JCS. The authority would determine whether a new or revised system was necessary. The JCS organization would be required to certify that a new need exists which cannot be met by the existing systems and the field commanders would be required to confirm that presently operational systems could not meet those need. Again, industrial organizations provide models for performing these oversight functions through their Boards of Directors who authorize program changes.

In short, participants designed an organization which would be autonomous, with oversight exercised sparingly, and only when events made that oversight essential to maintain the integrity of the acquisition process. Two directives issued by the oversight agency would assign responsibility and authority and would provide assurance of necessary resources subject only to the limitations of the funding authorization by Congress. The redesigned acquisition process appears in Figure 4 below.

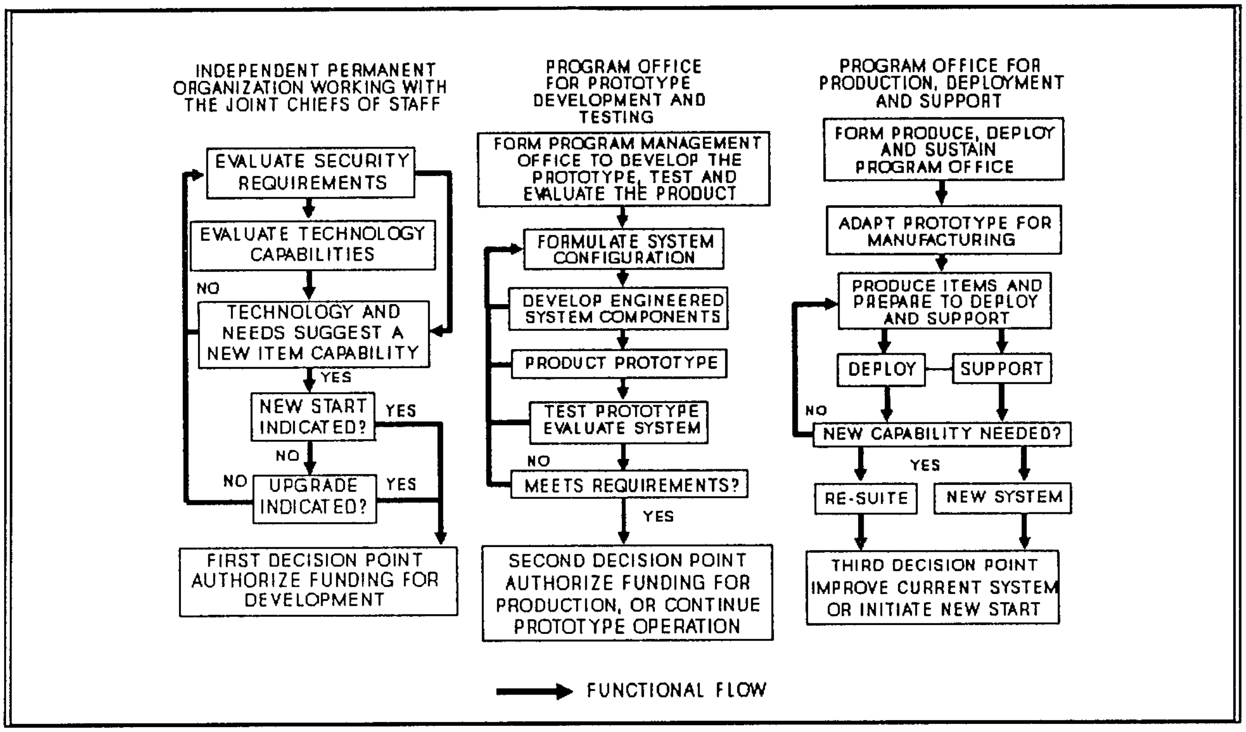

Figure 4
THE REDESIGNED ACQUISITION PROCESS

PROBLEMS WITH INSTITUTIONALIZING FUNCTIONAL ACQUISITION

After the functional acquisition process had been re-designed, a workshop was convened to evaluate its effect in reducing or eliminating the 678 problems (which had been defined as present within the acquisition process prior to Congress enacting the Federal Acquisition Streamlining Act of 1994 in October of last year). The participants in that workshop looked carefully into changes in acquisition policy resulting from Defense Department actions, and from the various Defense Management Reviews (DMR's) issued by DoD.

It was their conclusion that internal DoD actions had eliminated a substantial number of the problems already, and that institutionalizing the functional acquisition process would ameliorate or eliminate a great number of the problems which remained. In their judgement, ***612 of the 678 problems identified would be or had been eliminated.***

No problems remained in 5 of the problem areas defined in Table 3: DAB-DRB Process, Transition Management, Test and Evaluation, Credibility, and Oversight.

But what about the remaining 66 problems?

Table 5 indicates the problems remaining unaffected by institutionalizing a functional acquisition process. ***Most of the problems which remain have to do with the process of oversight and the way in which it must be exercised by law.***

Over the past 30 years, our society has developed an aversion to error that has lead to an unwillingness to accept mistakes no matter the reasons for making them. The record of predicting the future is dismal. The Chairman of the Federal Reserve Board has publicly stated that models which were formerly useful in predicting the economic state of the nation have lost their utility over the years. The inability of anyone to predict the future accurately is demonstrated daily when some prediction made years ago fails to materialize as expected. The problem is that change is so rapid there is little assurance that any long term projections will be accurate in the end. ***The unwillingness to accept the inevitability of humans making mistakes has led to a peculiarly structured system which affects all of us.*** The logic of that system appears to be as follows:

1. Mistakes are not inevitable; perfection is achievable through proper use of technology and paying attention to lessons learned.

Table 5

PROBLEMS LEFT UNSOLVED BY A FUNCTIONALLY DESIGN ACQUISITION PROCESS

GENERIC PROBLEM AREA	SPECIFIC PROBLEMS REMAINING
PROGRAM MANAGER AUTHORITY	❍ Political motives in the decision process ❍ No one can say "Go" but everyone can say "Stop" ❍ Interference from congressional oversight ❍ Proliferation and lack of accountability of ankle biters ❍ Political influences beyond the program managers' control ❍ Too many nay-sayers ... In the review chain ❍ Tendency not to surface problems ❍ Too many participants can stop or slow process without responsibility for delivering the product
CONTRACT REQUIREMENTS DEVELOPMENT	❍ Adverse impact of well meaning but ineffective attempts improve the process ❍ Data requirements ❍ Failure to adequately describe performance verification and validation process by which success is measured
TECHNICAL REQUIREMENTS MANAGEMENT	❍ Inability to synthesize a design the first time ❍ Changes in policy and specifications
FUNDING INSTABILITY	❍ Year-to-year instabilities to budget and procurement quantities ❍ Lack of fiscal planning
STATUTORY-REGULATORY	❍ Constraining procurement laws and acquisition regulations ❍ Excessive procurement laws and regulations ❍ Mandate for competition of small business that may be unqualified to participate

INFLUENCES	❍ Lack of regulation and historical approach cleansing ❍ Illogical competition ❍ Changes in policy and specifications
LONG RANGE PLANNING	❍ Acquisition process considers program/requirements on only an individual basis without considering larger investment context and trade-off ❍ Lack of or undisciplined strategic planning ❍ Lack of clear military strategy and quantitative military requirements ❍ Short-term planning dominates decision making process
USER SUPPORT	❍ Lack of priority by acquisition organization for weapon systems ❍ Lack of strong, consistent, and long-term user support for smart munitions programs
INTERNATIONAL FACTORS	❍ Inadequate foreign sales planning ❍ U.S. Security and custom regulation not consistent with international co-development

Table 5 (Continued)

PROBLEMS LEFT UNSOLVED BY A FUNCTIONALLY DESIGNED ACQUISITION PROCESS

GENERIC PROBLEM AREA	SPECIFIC PROBLEMS REMAINING
COST AND SCHEDULE ESTIMATES	❍ Unrealistic program plans/schedules and associated funding profiles ❍ Pressure for unrealistic schedule, cost, and performance ❍ Ineffective cost estimating up-front ❍ Competitive pressures lead to unrealistic expectations ❍ Assessment of program cost risk by DoD is inadequate ❍ Failure of contractors to propose realistic costing to RFP's (buying in) ❍ The government forces contractor to buy in thereby increasing the risk ❍ Lack of government understanding of the cost of procuring many smart munitions programs
INADEQUACY OF PROGRAM TEAM	❍ Loss of program focus due to program personnel rotation ❍ Lack of contractor's ability to provide people resources as required ❍ Lack of acquisition training of experience of superiors ❍ Inadequate resources outside the program office (doing more with less) ❍ Barriers erected between defense and non-defense divisions of companies and sectors
IMMUTABLE	❍ Instability of dod and congressional support for programs ❍ Abrogation of commitment at all levels ❍ Its never over ❍ there is no agreement between the executive branch and the congress on the long-term budget projection ❍ Congressional authorization and appropriation process ❍ Congressional mistrust and meddling and language
PROGRAM EXECUTION	❍ No OSD/Service policy on concurrent engineering ❍ Inability to award timely contracts due to external controls
EXECUTIVE AND POLICY MAKERS	❍ Leadership high turnover rate

RISK MANAGEMENT	O Failure to know how to respond to risks even when known (risk/penalty/profit) O Imprecise risk management methodologies O Management of the dod acquisition process is not disciplined enough O Lack of early management focus

Table 5 (Concluded)

PROBLEMS LEFT UNSOLVED BY A FUNCTIONALLY DESIGN ACQUISITION PROCESS

GENERIC PROBLEM AREA	SPECIFIC PROBLEMS REMAINING
INDUSTRIAL BASE	O Loss of industrial base (inadequate r&d) O OSD is a small customer of the general industrial base O Outward migration of investment capital and skilled people O DoD is unwilling to fund industrial base improvement program O Intervention is not an administration policy O Their present acquisition policies contain conflicting goals making it virtually impossible to strengthen the base O Lack of a clear understanding of the consequences of some of the perceived industrial base problems O Lack of agreement on the crucial or core elements of the industrial base that must be sustained O Failure to consider the industrial base early in the acquisition process O DoD fiscal management structure does not support and strengthen the industrial base (unit cost policy) O Need to formalize or institutionalize consideration of industrial base

2. Any mistakes which are made probably result from individuals attempts to gain their own ends.

3. Society must guard against making mistakes first by structuring the environment to minimize the opportunity to take incorrect action and secondly to provide continuing oversight which will insure that actions taken are in accordance with the structure.

4. If mistakes are seen to have been made, those who made them will be held accountable regardless of whether or not the action was eminently reasonable at the time it was taken.

The major difficulty with changing the way acquisition is structured results from the need to prevent any kind of error or misfeasance in expending tax monies. In the name of fiscal integrity, oversight and reporting requirements are levied to provide that assurance. To reinforce that point of view, a careful review of the testimony which led to the creation and passage of the latest Acquisition legislation reveals those same concerns shaped the bill. The record of testimony reflects the fears which have created and continue to mitigate against solving the problems listed in Table 5.

WHAT CAN BE DONE TO IMPROVE ACQUISITION PERFORMANCE?

The major difficulty in preventing technical and financial mistakes results from the requirement to forecast outcomes accurately very far in advance of the actual events. The closer a technical event is to taking place, the

more likely it is that predictions made about that event will be in error simply because so many things which affect the outcome of a process can change rapidly.

If we agreed that (a) planning five years or more into the future can best be done in general terms and that (b) detailed, specific forecasts of events which are scheduled to occur in the long term are likely to be in error simply because of what insurance companies call "acts of God", then a great many difficulties rooted in the inability to forecast perfectly would be eliminated.

Most technologists and engineers can see the shape of things to come quite well - and some can even project within a few years when technologies can (will) become useful in ways that can help create better materiel for our armed forces. Few, however, can detail those projections to permit accurate (errorless) planning even as much as one year into the future.

The workshops seem to tell us that we could improve acquisition performance greatly by providing oversight sparingly but at crucial times; and by recognizing that there are short time limits to long-term planning. Taking those actions can help us all. Corporate America is having to follow the new thinking about oversight and planning; perhaps there is a lesson in that for all of us.

ACKNOWLEDGEMENTS

Over three hundred and thirty individuals participated in the research program reported here. By contributing their understanding they made possible the insights into both the Defense Acquisition process and large, complex systems in general. Many of the participants are now directing large portions of Defense acquisition - and their understanding of the process they work within has improved the products the Acquisition Corps provides for our fighting forces.

Henry C. Alberts
February 1995
Fort Belvoir and McLean, Virginia and
Bethany Beach, Delaware

Can "IPD" Work in DoD?
(How About Lean Practices?)

Lieutenant Colonel Mikael S. Beno, USAF

ABSTRACT

In order for the Department of Defense (DoD) to accomplish its mission, new ways of doing business must be created. Manpower reductions alone dictate this. Integrated Product Development (IPD) may be one way to require managers to face this fundamental paradigm shift. This paper discusses IPD tenets (empowerment, product focus, up-front planning, right person/place/time, seamless management tools, and teamwork and communications) and their relationship to lean engineering principles. In addition, this paper answers the questions, "How do IPD tenets and lean practices result in better management and improved products, and what are the risks and manpower implications?"

CAN IPD WORK IN DOD (HOW ABOUT LEAN PRACTICES)?

INTRODUCTION

The purpose of this paper is to analyze and discuss Integrated Product Development (IPD) tenets and their relationship to lean engineering principles as discussed in "The Machine That Changed the World." How do IPD tenets and lean practices result in better management and improved products, and what are the risks and manpower implications? Finally, as you read through this article, answer the questions "What is a lean organization" and "What are the limitations of employing lean practices in DoD?"

HISTORY

Air Force Materiel Command (AFMC) has sent out the word that all centers will use the concepts of IPD, but there appears to be a wide gulf on progress toward implementing it as well as explaining its tangible values. The reactions to this "new" concept have been varied, but more often than not the most common are some combination of "IPD is just another buzzword, it's just plain old common sense, or IPD is really nothing new."

Lean engineering and manufacturing principles are the precursors of IPD and are a major foundation on which the tenets of IPD were developed. Information in this article on lean engineering and car manufacturing concepts was taken from the book "The Machine that Changed the World."

Lean car companies show a reduction of engineering design hours on major projects by 40%, schedule by 25%, and improved quality when comparing data with companies using traditional methods. How do they accomplish these significant improvements, and do the factors that allow this apply to the DoD acquisition process? What is the impact of not fully integrating IPD into the DoD culture? Is the acknowledgment of a paradigm shift a necessary precursor to success?

> Piecemeal imitation of successful organizations is a common reason for failure in efforts requiring significant change (Wilkins).

TENETS OF IPD

IPD is comprised of no less than seven separate tenets. All of these tenets (empowerment, product focus, up-front planning, right person/place/time, seamless management tools, integration, and teamwork and communication) merge to

result in a new approach to doing business, in essence, a cultural change (which AFMC says itself is a tenet). Each tenet, what it really means, and its relationship to lean engineering will be discussed.

EMPOWERMENT

What is an empowered leader? How do you know if you are empowered? Why do you want to empower your people? Empowerment requires at least two confident and capable people and is a function of a supervisor's trust in the employee's ability as well as his ability to relinquish control. This is a most difficult concept for managers in large bureaucracies, particularly when it is expected that managers themselves are held accountable for every facet of a project. This has resulted in a form of micro-management and a reluctance to allow people to function without constant reviews and approvals. This mentality applies to contract management as well. We continually conduct reviews and audits of our contractors. Why? Don't we trust them? You can not expect to have any significant improvements in productivity without trust. If we were to trust our contractors, and minimized reviews, audits, and the like, what would be the impact on manpower, particularly within the contract administrative areas? Until we change the reviewer mentality that currently exists among all of us and begin to put a much higher burden on the contractor for product success, it will be difficult to change the process, or the level of productivity. Lean companies trust. The trust is based on clear expectations expressed in contract language. The first step toward being lean is to empower the contractor to do the job and get out of his hair. A necessary condition for trust is to write better RFPs.

An empowered person is not a coordinator of functional inputs (which many program manager's are today) but has real control of the project. Do you as the project leader write the evaluation reports of the functionals on your team (isn't this the essence of real control)? The simple answer for most is no. In fact, a recent AFMC 500 series regulation provided guidance to centers that team functionals would be rated by the functional three letter, not the IPT team chief. This is not lean and it is not IPD. The primary reason for this is that as organic manpower resources diminish, the ability to put full time functionals (i.e., engineers, data/configuration managers, contracting officers, logisticians, etc.) on teams will decrease. People will be spread thinner over more contracts and the ability to justify rating personnel by IPT team leaders will drop. Nonetheless, a return to matrix management, for whatever reason, is not IPD.

If you are empowered, your boss gives you decision making authority commensurate with your experience level (decentralization). Look for examples in the

management of your program. What functions are you not the final decision authority on in which you should be? Go to your boss and get them changed. If you find resistance, the primary cause will most probably be a failure to understand IPD and the resultant paradigm shift away from centralized decision making. Managers are still afraid of the ramifications of not being able to answer their boss's questions.

Why are we trying to foster empowered leaders? With decision making made at the lowest possible level, you can expect to see fewer middle managers and a reduction in preparing and delivering time consuming briefings. This, both within the government and with our contractors, can have a significant impact on manpower. In addition, senior leadership will be not only developing the leaders of the future, but in a study conducted on an individual's choice of more pay or greater authority on the job, a vast majority took the additional authority. People want to feel ownership and be accountable, and this makes for a happier and more productive worker. The bottom line-IPD means empowered employees and contractors, and DoD needs to brainstorm areas in which to implement this tenet.

PRODUCT FOCUS

Ask yourself the question, what were the functionals most interested in under the old system, namely pure matrix management? What was the focus? More times than not wasn't it that their CDRL, or their SOW paragraph got into the contract? Were they interested in what some other functional was doing, or a problem not associated with their area? The answer to all of these questions is probably no because rewards and penalties were (and continue to be) oriented toward individual accomplishment, not the team. The term "functional stove piping" was coined to indicate this mentality. Under IPD, the primary focus is the product not the functional ritual of submitting their SOW paragraph or CDRL. This new focus starts with each individual of the team understanding what the customer really wants. In Steven Covey's book, "The 7 Habits of Highly Effective People," his habit number two is "begin with the end in mind." What are we really trying to do-what is the bottom line? It is not to develop paper but to put reliable hardware in the hands of our defense forces. In order to develop and field the product to the users in a timely manner, it is absolutely critical that all team members understand what the customer wants, and that brings us to the "requirements" process. If this process is broken, then the acquisition phases (Post milestone 1) will be prone to a wide variety of future problems.

The requirements process is in need of repair. In one study chartered to look at this problem, some of the major findings were:

1) Little or no pre milestone 0 work is being done (MAA, MNA) resulting in products being developed because technology exists, not because there is an operational need. We

field products with often no quantifiable understanding of its impact on the outcome of battle? This, of course, should be determined prior to expending post milestone 1 resources.

2) The user does not have the necessary acquisition/technical skills or budget to accomplish pre milestone 1 activities alone. This results in a need to clearly define roles which current regulations fail to do. It is clear that users are responsible for all pre milestone 1 tasks, but who should be doing them? Confusion results causing a variety of ills (false starts, team disunity, etc.)

3) Centers can not "satisfy the customer" if requirements are not clear. The AFMC product and logistics centers are the customers of the requirements process. The users are the suppliers. ORDs must be delivered on time, provide for trade space (no solutions), and be traceable (which requires common, user friendly traceability tools) back to the functional objectives of the MAA. Sadly, for most programs, these issues are symptomatic. How do we change?

Our relationship with our customer must be clarified. Current regulatory guidance is not clear. An overarching MOA between acquisition centers and their customers which clarifies roles is needed, and individual team charters talking to products, with the "who's" and "when's" attached, are first steps. Team training with all the players (SPO, user(s), and contractors) using the same game plan is clearly needed.

UP-FRONT PLANNING, RIGHT PERSON/PLACE/TIME, AND INTEGRATION

How would you score DoD on up-front planning? For example, how would you explain why there are so many ECPs, schedule slips, cost overruns, or misunderstandings resulting in claims from our contractors or complaints from your users?

The primary cause of schedule delays and cost overruns is the failure to properly plan acquisitions (or is it changing requirements, arguably a subset of planning). In order to solve this problem, more up front planning is required, but what specifically? What is the primary product of a center? Isn't it the request for proposal (RFP)? And what could be used, both as a way of ensuring the contractor is capable at contract award and as a way to manage the program? IPD suggests seamless management tools are the answer! These tools are covered in more detail later on.

Historically, there have been many cases where this up-front planning has simply not been done. RFPs are prepared by junior officers who have little experience. Documents are reviewed at the end (murder boarded) versus building in quality. This usually results in changes and increases in the time it takes to get out an RFP (and consequently providing the product). Time phasing of activities is not considered and many times arbitrary dates are set for

contract periods of performance. Documentation is either not prepared, not provided in time, incomplete, or prepared by a sub-optimal team. These symptoms, one might guess, could be found throughout DoD.

People who understand both the requirements and acquisition processes, and the role of system engineering are critical and valuable resources in DoD. Few of these people exist. This means that in view of the fact that DoD does not have the resources to allocate a full person to each team, teams must have the **right person,** at the **right place,** and at the **right time.** Work force reductions will continue to challenge our young people and overtax our experienced ones. IPD in this environment will require more emphasis on planning and teamwork and less on empowerment as the trend is to stick with matrix management. Both up-front planning and the right place/time place tenets dictate that a trained IPT must be in place.

In order to ensure that up-front planning is conducted, IPTs are assisted by organizations called RFP Support Offices at AFMC Centers. Some centers combine experts who know IPD, RFP documentation and source selection, and technical analysis into one staff. This staff assists SPOs with tools, documentation, timelines, and strategy. It is this independent organization which ensures an integrated approach is considered and applied. **Integration** (another tenet) means not only that teams are in place and working together, but that the contractor's plan to produce a product is integrated (time phasing of tasks and the tasks themselves among all the functionals) throughout the total program (again, see seamless management tools).

SEAMLESS MANAGEMENT TOOLS

Few people in AFMC product centers build any hardware. In a way, our product is paper such as an RFP, and our customers are the contractors who try to figure out what we really want. In addition, we manage. Seamless management tools are used for both source selection and management, and that is why they are seamless. Prior to IPD, seamless tools did not exist. One major problem was that the technical proposal of the contractor were not made part of the contract. He could promise the world, but it was the contract language that was taken to court, and his proposal was generally not a part of it. When it came to explaining his understanding of a variety of functional areas, little real information was forthcoming. We needed a system which required the demonstration of the ability to accomplish the work, not a marketing pitch That is why a major change to the RFP process was called for and is called the integrated management framework, or IMF. Under this planning approach, there is first a simple, orderly progression and relationship from the specifications to the work breakdown schedule (WBS) to the statement

of work (SOW) using a common numbering system. In addition, this approach adds two tools: the integrated master plan, or IMP and the integrated master schedule, or IMS. The beauty of these management tools is that it makes the contractor develop, prior to contract award, both IMP, (akin to the SEMS), IMP narratives (related to the SEMP) and an IMS (akin to the SEDS). See Mil-Std-499B for more information on SEMP, SEMS, and SEDS.

The IMP is incorporated into the contract as an attachment and is based on the contractors understanding of the programs key events, significant accomplishments that must be concluded in order to hold an event, and how one determines if an accomplishment is successful. It is a management tool used for both source selection and post award administration. The reason this tool is so effective is it forces the contractor to demonstrate the actual plan for the entire program. The most common complaint from contractors is that it is too expensive to build (particularly with no assurance of winning) and requires to much up front work. This indicates that in the past many of these contractors did not accomplish the necessary proposal preparation which resulted in a propensity to rely on ECPs to get well.

The IMS provides a detailed schedule (calendar dates) to meet those events. This new IMF also calls for narrative summaries. These plans, which address areas such as configuration, quality, manufacturing, etc., were previously provided by CDRL after contract award. Narratives are now provided to the source selection team and show not only the key processes (as opposed to them spitting back a Mil-Std), but how they all integrate.

TEAMWORK AND COMMUNICATION

Under the old way of doing business, team players operated more or less in a functional vacuum. Now inter-functional interaction is being asked for where team players work both inside and outside their own particular area of expertise. Why? Because, when this was done by the Japanese in their plants it was found that the gains of even a slightly less proficient expert were offset by the gains in team problem solving and product improvement. Does this mean that by sitting and working issues together that one could expect a better product faster? The answer is yes. How does it work? It's quite simple, really. To expect a functional expert to be the only person capable of solving a problem effecting his area is shortsighted, but we have been operating that way for years through out "stovepiped" relationships. Team members can bring a variety of perspectives and potential solutions to processes and problems that they are not the expert on. This assumption is intuitive. A well balanced, motivated and capable team, with competent leadership can produce products

that far out perform those of stovepiped teams.

Teamwork also involves establishing proper relationship of the team leader to the workers. First of all, as mentioned earlier, if a leader is going to have the full attention of the members, the functionals must report to and have his personnel evaluation done by the project leader, not the functional head. The functional head's job is to provide qualified people to the team, not matrix manage (at least not under the lean or IPD culture). Secondly, under lean practices, people are assigned for the life of the project. Why?-- To keep people in their jobs where they can make use of all their experience and training! This points to civilianizing many acquisition jobs. Thirdly, the team must have goals and objectives and as such, they should be written down in some form of a team agreement (charter).

The cultural hurdle though which is most distressing to overcome is to get the proper number of people involved up front. There is a reluctance to staff an organization during the most critical phases (CE and Dem Val). It is generally during this time that organizations are begging for resources. This is not lean, but is the old mass production mentality. Not having the **right people** early on (**right time**) delays problem solving and causes major cost problems later on. It is the leader's job to encourage conflict among his team when the impact of change is minimal. In order to do this, he leads the group into an agreement on how to handle conflicts and documents it. This healthy conflict should result in a number of potential alternatives which will require these professionals to mix solutions, risk, and costs. These alternatives, and resultant trade studies, are the business of our product centers using the discipline provided in Mil-Std-499B, and therefore center involvement is mandatory, particularly during Phase 0 when the payoffs are so high. Team composition in a lean organization shrinks over time. This is just the opposite of mass production (or government approach) where teams are generally small and grow over time. No foreseeable change is expected within DoD unless we improve our up-front planning, use seamless tools, and empower all the players.

LEAN ENGINEERING PRODUCTION

The previous discussion has been on how the derived tenets (from lean practices) of IPD can be employed in DoD and their limitations. But lean engineering also involves a number of other concerns. Most of these have to do with the actual production of the hardware and subcontract relationships. The successes of these techniques have been a major motivater for incorporating lean practices in companies outside Japan. The focus also has been high volume manufacturing. In DoD, should we try to incorporate these principles into low volume manufacturing or even non-manufacturing "white collar" areas, such as

the SPO management process? Should we be attempting to make our contractors implement lean practices. If so, what influences do we have in making an organization or a contractor lean and what kind of success can we expect?

What kind of data can be used to show the value of lean engineering/production? Let's compare US traditional methods of manufacturing and engineering against the Japanese lean practices.

1) The average car company team size: US-1421; Japan-333.

2) The average number of engineering design hours: Japan-1.7 million; US or European manufacturer-3 million.

3) The amount of time it takes to field a car: Japan-46 months; US or Europe-60 months.

How is this possible and more importantly, can we expect similar improvements to show up in government acquisition?

In preparing the RFP, all the IPD tenets are applicable and can result in huge savings in managing programs. However, in achieving the type of savings listed above, those savings must be made by your prime contractor. These are manufacturing or engineering savings. What can the program manager or the government do?

One of the most critical issues in achieving these savings is in your contractor's relationship with its first tier suppliers. How are Japanese companies so different from their US or European counterparts, and secondly, what are the government's limitations in implementing these ideas? Supplier (or subcontractor) tenets may be laid out into four major categories. As we go through them, think of how DoD could use them to make a difference.

SUBCONTRACTING RULES

What should be the role of the government in order to be a lean organization? Do our rules on subcontracting result in lower prices, higher reliability, or better quality? Whether a contract is anticipated to be sole source or competitively awarded, the contractor IAW FAR Part 19 and/ or 52, is required to follow certain clauses (and to administer them). The sheer number of the clauses effecting the relationship between the prime and the sub is staggering and totals around 100. These clauses effect areas such as quality, inspection, warranty, sources, management, security, examination of records, audit, use of SB/SDB, EEO, patents, CAS, competition, incentives, rights, data, markings, and proprietary rules. What impact do all the clauses have and how is it different from lean production? The contention could be made that ensuring all these clauses are followed does not add anything to the product, but it is expensive. None of these clauses either by themselves or together has anything to do with being lean. For the most part, they are purely administrative and increase the indirect cost of a part. Could they all be removed from

the books with no impact to the quality or the cost of the product? This is an example of the government's micro-management approach which burdens the customer and does not place responsibility or real penalties for non-performance on the contractor. The government is focused less on quality or reliability and more on price and social programs. Our procedures are the antithesis of a lean organization. If the rules must remain, remove the need to check on them. Trust is lean.

TEAMWORK AND TRUST

In industry as well as government, simple parts will have multiple suppliers. Complex parts may have only one. There is a flawed perception that developing a second source is the only way to protect the government from overpricing. This is not lean thinking because pricing and cost considerations are based on a mistrust of the industry, not on teamwork or long term relationships. The concepts of teamwork and trust are lean. Subcontractor relationships to the prime are considerably different in a lean production culture. In cases the prime holds stock in many of its first tier suppliers. In fact, it is common to see mid level managers of the prime being assigned into the management structure of one of it suppliers. But the real key to effective supplier relationships starts with the contract between the two entities. In the US, the basis for award is price. The automotive industry also has its share of "buy-ins." The primes know this and actually estimate the rate at which parts can be expected to rise in price. Contracts are generally for one year with options. The amount of trust is minimal as numerous times subs have lost the ability to get back their tooling or investment costs on multi-year option contracts when the prime goes out at the end of the first year with either a new invitation for bid (IFB) or decides to do it in-house.

In the government, subcontractor prices are either 1) competitively determined by the prime, 2) the contract is not subject to audit due to a determination of "adequate price determination", or 3) subject to a DCAA audit for determining cost. The point to be made here is that the cost of an item is not subject to any type of "value analysis". Value analysis is the continuous identification of critical costs and steps with a goal of incrementally improving them. The profit of an item may be low (and the government goes to great length to insure this, i.e., fair and reasonable), but the total price is still quite high because the elements of costs are not targeted for improvements. Did the government "do good"? Many would say yes unfortunately. The goal of the prime should be to minimize the price while maintaining a reasonable profit. This does not occur in the government. How does the lean producer work?

First of all, the basis for award is not price. It is reliability and performance. Next, the prime and sub jointly determine the

initial price through the sharing of technical and cost data. That does not occur today in the government or in most US companies. Next, this partnership looks at ways to reduce the cost of the part through "value analysis," and the prime incentivizes the sub through value engineering sharing relationships. The prime expects the costs to go down over time, not up as in the US model. The basis of this relationship is the primes long term contractual commitment to the sub. The sub shares information with the prime not only in the cost area but in the technical area as well. It doesn't hide it for the sake of future negotiations. Sometimes the prime might employ two subs in a sharing of orders. However, the basis for future splits is not cost, it is again reliability. The reason it can do this is because the foundation for future pricing is one of teamwork, trust, and an understanding that the prices will go down, not up. Can DoD primes do this on individual contracts -- probably only in a few cases due primarily to the relatively low quantity orders. The trust through longer contracts and team interaction, when coupled with DOD's budget instability, results in these types of relationships being more an exception to the rule than the rule.

INTEGRATION

The next area has to do with the "amount" of integration, which is another success story for lean production when compared to its US counterpart. US manufacturers will, for example, order all the parts that make up a car seat, and then assemble it at the plant. Japanese asks the sub to not only assemble the seat, but to design it as well. What does this mean? It means that not only is the prime not interested in all detailed design, but the number of parts ordered by the prime is reduced, and with it all the indirect labor that goes with both. Lean producers add only 27% value versus 70% for GM. In addition, only 30% of the part are detailed designed by the prime versus 81% for GM. What this results in is that GM models have 3-8 times the number of suppliers as Toyota, and roughly 6000 people in purchasing versus 337 for Toyota. How could this be applied to DoD contracts? Can you as a program manager get your DoD prime to somehow increase their sub's portion of the design and reduce the number of parts delivered? Do you really care, particularly if it is a competitive environment? It is very doubtful whether or not the government would want to get involved in the breakout of parts and design. Component breakout is manpower intensive and is less and less attractive. Directed subcontracting shifts the burden of failure to the government. Savings in this area appear marginal in government contracts.

DELIVERY AND INVENTORY

The last area has to do with delivery. Lean producers utilize just in time (JIT). In 1983, 70% of US suppliers delivered once a week. In Japan roughly 16% deliver once a week. So what's the difference? Looks like the US is doing pretty good! First of all, the other 84% in Japan's case are delivering on daily and sometimes hourly rates, so the statistics are misleading . The more fundamental question might be "what is the big deal with JIT"? It seems to add a high amount of risk if supplies don't arrive and the line shuts down! JIT does two things. First of all it mandates higher quality standards exactly for the aforementioned possibility, a shut down of the line. Remember, quality requirements as well as delivery are part of the prime and subcontract arrangement. In the US, quality is determined generally by a percentage of bad parts in a lot. If it's higher than allowed, the entire lot is rejected. In lean, because the delivery schedules are so frequent, bad lots are smaller, and fixes can occur much sooner.

In addition, the cost of holding large inventories is an expense. Neither the prime nor the sub wants this. So one might expect to get higher quality at lower cost with a JIT system and that is the impetus for so many US companies moving in this direction. But the statistics are misleading for another reason. Although the weekly delivery rates have improved, US primes are still requiring subs to hold inventories and subs are continuing to build in large lots. More frequent deliveries are not due to any real lean production techniques.

Can you as the program manager effect delivery schedules of subs? Again, the question must be asked, do you even want to get involved? What kind of risk does JIT add to your schedule? For low quantities, is it even desirable? JIT has been a fundamental reason for Japanese successes, but it applicability to government contracts appears minimal.

RECOMMENDATIONS

Based on the discussion above, what should DoD be focusing on in terms of becoming a lean organization? If IPD is a desirable management philosophy, we need people who understand its limitations and applications, particularly in view of future massive manpower cuts. Here are some recommendations, first in the area of IPD tenets, and secondly in production and supply.

TENETS

Managers at the senior level must address the paradigm shift required of empowerment for both its in-service employees and contractors. Decision making must be decentralized. IPD offices at headquarters and at the centers should be brainstorming areas where manpower could be saved by empowering its people. To move from "stovepiped" relationships that are more

concerned with process to true IPTs teams focused on products, IPT leaders need to be empowered with real authority for members, and teams need to be trained as teams with their customer. Little training exists today. RFP support offices are not being fully utilized to ensure up front planning is a disciplined process. This needs to be beefed up and should be reviewed by all services to see if it has wider application.

Seamless management tools and their use in DoD appear to be moving slowly. The reason for this most likely is that few people understand them (IMP/IMS). These tools as pointed out work with a number of the other tenets to improve the chance of a quality product. The problem is few people are willing to change, or understand, how these tools work. If these are the tools that make sense to use, lets get behind them and train people on their use.

Teamwork is absolutely essential between not only center functionals, but with our customers and contractors as well. Training the IPT as a group is a must. More problems with satisfying the customer come from the inability to understand what is really wanted than anything else. A charter laying out these understandings is one method to ensure communication, and roles are clear. A charter is recommended for every IPT which addresses such items as mission, schedule, documentation, roles, products, processes, and decision making rules.

PRODUCTION/SUPPLY

Finally, what can DoD do in the area of supplier relationships to reduce the cost of business? First, there are a number of streamlining initiatives at high levels looking at ways of cutting down on the number of laws effecting acquisition. This is positive step if and only if some tangible action results. Past initiatives have resulted in great ideas but no change. DoD needs to look at the laws effecting supplier relationships specifically to see what changes can effect quality, cost, and reliability.

How do we incentivize teamwork and trust? It does appear that the idea that a sub would ever trust its prices or technology to the prime is un-American. The only reason it is done in Japan is that the prime owns part of the sub, so there is a mutual benefit.

How can we institutionalize "value analysis"? In the areas of integration can we incentivize the reduction of engineering design hours and piece part build-up at the prime's location? How? Why do it?

What are the risks associated with JIT delivery systems, particularly when parts are extremely expensive and complex? Is it even a player in low quantity manufacturing?

CONCLUSION

IPD implementation is moving very slowly for two reasons. Few people understand the process and there are few

people who can teach them. Another major issue is change, and people's natural reluctance to try something new. IPD works. Industry is employing it. But the people in DoD who can impact change have been working for so many years under one set of rules that to learn a new technique is difficult. In order for DoD to accomplish its mission, new ways of doing business must be created. Manpower reductions alone dictate this. IPD requires managers to face a fundamental paradigm shift, and those who can't, or won't face it, are going to find success difficult. It is for this reason that a **cultural change** is required. IPD if not the whole answer, is certainly a step in the right direction.

There continues today to be many questions on what to expect out of this new philosophy of IPD. Production savings and management applications appear difficult and hard to find. The purpose of this paper has been to get you thinking!

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A Feasible Reform of Software Procurement Using Software Process Improvement

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Abstract

The U.S. Federal Government significantly underrewards investment in quality in its software procurements. This paper presents a formal theory for why the underinvestment in quality occurs. The theory stresses differences in the measurability of dimensions of performance and the dysfunctional incentives for government and industry managers from too great an emphasis on the measurable. We present evidence that software process improvement (SPI) is a means for increasing attention to quality in government software procurement. Based on our findings, we conclude that: 1) the government should consider incentives for SPI, 2) reduce reliance on incentives for cost and schedule performance, and 3) ensure the government fields reliable methods and effective teams for evaluating contractors' SPI efforts.

1.0 Introduction

The U.S. Federal Government has had grave difficulty acquiring software, an increasingly important component of both military and civilian systems. Most software acquisitions take much longer than planned and cost a lot more than budgeted. Acquired systems do not work as planned, if they work at all. Perhaps General Bernard Randolph, commander of the U.S. Air Force's system procurement organization, summarized the government's problem best when he opened a 1989 international software conference by stating that, "The Air Force has a perfect record when it comes to software procurement, we've been late and over budget on every program."[1] The record on software quality is almost as perfect: few, if any, systems accepted and paid in full can fulfill their intended functions without considerable rework.

Software procurement successes are extremely rare for systems of any consequential size and complexity. Software procurement disasters, systems that cost too much, take too long, and do not work as intended, are, however, common: the Federal Aviation Administration's new air traffic control system, the Internal Revenue Service's processing systems, the U.S. Air Force's Peace Shield program for Saudi Arabia, the Department of Commerce's next generation weather radar, either the original or the current upgrade to the Department of Defense's (DoD) Cheyenne Mountain complex, and the Department of Commerce's new patent administration system are but a few example disasters. Even when success is declared at some point in the course of development and implementation, latent defects may strike later converting an apparent success to a dismal failure; e.g., the AT&T phone switch or Clementine spacecraft.[2]

The sources of the government's difficulties in software acquisition are extremely complex and much studied. There are an extensive academic literature and the reports of many commissions and organizations on government acquisition (see, for example, [2-9]). Many of the reforms recommended in all of this prior work have not been implemented. Those reforms that have been implemented have not demonstrably improved the software acquisition process. Some reforms, such as placing software standards into contracts across-the-board, have actually been detrimental by not accommodating industry's evolving best practices, forcing the Defense Department

[1] Keynote Speech, 1989 Tri-Ada Conference, Pittsburgh, PA, October.

[2] See [1] for a more extensive discussion of the difficulties the government has acquiring large software systems.

into yet another revision of their software procurement standards.

The roots of the government's difficulties in software acquisition are in dysfunctional incentives for both government procurement managers and software contractors. Several factors make the incentives dysfunctional. One major contributing factor, particularly in defense software acquisition, is the regular separation of software contracts into development and maintenance phases with different groups doing each phase. Developers know that they will not have to live with the consequences of any quality problems with the software they develop because it will be some other group's task to make the software operational and to maintain it. The developer's main objective is to get the government agency to accept and pay for whatever it is that they develop. Developers enjoy further protection from the negative consequences of producing poor quality software because the government makes inconsistent and infrequent use of past performance information in the selection of firms for new software development projects. Past performance, good or bad, simply does not matter very much to your prospects for getting new software development business from the government.

Another important contributing factor to dysfunctional incentives and the primary focus of this paper is differences in the measurability of dimensions of performance in writing and enforcing contract provisions. Cost and schedule are nominally easy to measure. For the government customer, software quality is difficult, often impossible, to measure prior to extensive operational experience with the system. There is considerable oversight[3] pressure in government acquisition where the "public's money" is being spent to emphasize the measurable dimensions of performance throughout the contracting process. Software quality often gets short shrift because individual careers are much better served by association with projects that may produce poor quality software but that are on schedule and under budget than by association with projects producing great quality software over budget and behind schedule.

This paper utilizes a "principal-agent model"[4] to examine government and contractors' incentives in software procurement. We provide a theoretical explanation for why existing incentives in software acquisition are detrimental to software quality. We also use the model to explore how the government can provide indirect incentives for better software quality. The model explores incentives in a process with two easily measured dimensions of performance, cost and schedule, and one difficult to measure dimension, quality. We extend the model to consider software process improvement (SPI) as an approach for improving incentives in software procurements. We close with several recommendations for software procurement reform.

2.0 Incentives in Software Acquisition

The incentives for government and industry managers center primarily around issues of cost and schedule performance. Glenford Myers, one of the early researchers to document the importance of software quality, asserted "We try to solve the problem by rushing through the design process so that enough time is left at the end of the project to uncover the errors that were made because we rushed through the design process" [17]. Myers is alluding to a common industry practice of rushing through software development in order maximize revenue, with the end of the project left for the firm to "build-in" quality until the government takes acceptance. As an illustration, in the opening statement of a recent program review meeting for a multi-billion dollar, software-intensive

[3]Approximately 40 percent of every federal procurement dollar goes to management oversight. Five to fifteen percent is typically allocated for management oversight in the commercial sector [9].

[4]The Principal-agent framework is very flexible and has been used to study risk allocation in share cropping [10], insurance markets [11], education [12], and measurement in organizations [13]. Several researchers have used this framework to study general government acquisition [14-15] and software development for internal use in large commercial organizations [16].

government procurement, the president of the contracting firm told his customers that "the software is done, we're just trying to get it to work."[5]

Government managers are evaluated primarily on their ability to contain costs and meet schedules. Most of their training involves understanding and constructing budgets and schedules, attributes of procurement that are easy to quantify and understand. Explicit cost and schedule incentives are the rule in contracts. Explicit contractual incentives for software quality, attributes such as reliability, maintainability, or number of defects per module of software, are rare. Government and industry managers attend primarily to explicit contractual provisions. Software quality is never very explicit and never gets much attention.

The incentives for cost and schedule performance are usually found in contract clauses or award fee pools. Sometimes, additional profit is tied to meeting schedule or cost targets or achieving superior system performance. Abstractly, industry receives progress payments by expending effort on specified tasks in their contract. As the actual cost of a task rises toward the task's budgeted cost, the government responds with payments up to approximately 80 to 90 percent of the budgeted cost. These payments arrive even though the actual cost of work performed may have no relation to whether a task is 25, 50, or 80 percent complete. This is especially critical during the early phases of a software development when rigorous measures of outcome or quality are virtually non-existent.

A great deal of pressure is applied by industry and Congress to reach schedule milestones as soon as possible. Most government managers are only too happy to accommodate because their evaluations also hinge on accomplishing these milestones. Further pressure may come from Congress in the form of the dysfunctional practice of cutting the budgets of programs that are late or over budget. This irrational behavior almost always drives up the life cycle cost of a system.

A reason for much of the obsession for cost and schedule performance lies with the infeasible budgets and schedules that the political system forces on government and industry managers. It is such a major problem that, at this writing, a major study is underway within the Office of the Secretary of Defense to document the widespread cost growth of programs within the DoD. A preliminary version of the study found that "for over several hundred procurements, in almost every case, [actual] costs in each program as they have matured grossly exceeded the projected costs" [18].

Cost growth, a problem plaguing government procurement throughout our history, occurs as a result of a combination of factors:

- The political system fails to fully fund programs, thus stretching out their development life and cost;
- The agencies deliberately underestimate costs so that Congress will initially fund a project, thereby establishing a powerful constituency for the project;
- Software-intensive contracts are awarded to inexperienced firms; and
- There are major technological uncertainties, particularly in defense procurements, as government agencies often pursue aggressive performance targets while paying little attention to issues of cost containment [3-4].

Government managers procuring software routinely work with "shortened" schedules and "reduced" initial budgets to meet requirements that are sometimes technically unattainable given the funding and schedule constraints. The oversight for government managers doing acquisition is oppressive with layer upon layer of investigators and controllers. The dominant incentive is to meet the measurable performance standards, not to solve the government's fundamental

[5]Private communication between one of the authors and the government contracts manager for the affected program during the summer of 1993. The referenced executive program review took place on March 2, 1993.

acquisition objective of achieving quality software, software that will accomplish the intended government functions, at a reasonable cost in a reasonable length of time.

Dysfunctional incentives for firms also arise from government procurement officials' inability to use past performance information rigorously when selecting firms for new developments. Unlike the commercial sector, where consumers (firms or individuals) routinely consider how well a firm performed in the past as a guide to how they might perform in the future, government managers are severely constrained in using past performance information about a firm when making a procurement decision. Firms know their inattention to software quality in one development will probably not hurt them when bidding for future procurements. So, the standard operating procedure within many firms is to rush through development and hope that the integration of hundreds of software modules into a system will yield a level of quality that the government will accept. This problem snowballs as most government managers, facing significant schedule and financial pressure, become willing accomplices to the procurement of poor quality software by accepting software products much too soon.

- **How The Incentives Affect Software Quality**: Government procurements are separated into software development and support. Different managers are responsible for each phase and each is graded only on their phase. This is especially significant for software development procurements because a significant part of a software system's life cycle cost depends upon the quality of the products from the development phase.[6]

Inattention to software quality is a cumulative problem. Government managers are evaluated on cost and schedule performance for development, not for the system's full life cycle. So during the development phase, managers are motivated to cut corners and take delivery of a system at the earliest possible date, even though corners cut may end up costing the government 10 to 100 times as much over the life cycle of system [19-22]. The earlier a defect is introduced in a development and the longer it is allowed to persist, the more costly it is on average to remove when it is found.[7] Poor software quality is very expensive; at least 40 percent of a system's cost is spent on system support after the system is delivered to the user[8]. Estimates of how much system support is allocated to maintenance range from 17 to 100 percent.[9] The quality of the software affects how much of that software support is maintenance. The lower the quality, the greater the maintenance. Thus, managers that accept poor quality software during development are pushing defect identification and removal into the system's support phase, where defects are usually much more expensive to remove.

An emerging approach for overcoming the lack of management attention to software quality uses "measures of *Software Process Improvement*" as an easily measured proxy for software quality. These measures reflect the rigor of an organization's software

[6] A system's life cycle cost includes all research and development, production, and software support.

[7] There are many reasons for the high expense of maintenance, but the re-engineering that often goes on after delivery is viewed as the main culprit. In most cases, key developers and designers do not stay around for the support phase of a system. They move on to new challenges, for they are usually the developing organization's most important assets. Consequently, personnel performing software support are often not only new to a system, but they also usually work with documentation that does not match the current system or undocumented software. In personnel terms, it is much like comparing the knowledge of an auto mechanic with that of the engineer who designed and developed your car.

[8] See, for instance, [20, 21, 24-29].

[9] Some sources are [26], 17 percent; [20], 100 percent; and [29], 63 percent. The problem with these data and collecting such data in general is the lack of uniformity across industry on what constitutes maintenance. The data provided by Lientz *et al.* do not include such items as improving documentation, recoding for efficiency, or environmental changes under the maintenance heading while other researchers would consider those maintenance activities.

processes through issues such as, "Do they provide training for their developers and managers?" and "Do they measure the performance of their processes and products as a normal business practice?"

3.0 Public Policy Options

The problems in acquiring quality software products are so obvious and well-understood that direct solutions that in one way or another reorient a firm's incentives are inviting. These solutions include holding firms accountable, awarding life cycle contracts, or restructuring the basis of payments for firms by employing a measurable proxy for software quality.

• **Hold Firms Accountable:** The most direct solution is to merely require that firms deliver high quality or we will take our business elsewhere, in much the same manner as we behave as consumers. If your sink is leaking and you hire a contractor to fix the problem, you may have to pay 50 percent up front and the remainder once you see that your sink is no longer leaking. With software, however, work that appears completed today usually contains latent defects that strike a system in the future under certain, typically unforseeable conditions. Another difficulty is establishing that the quality problems stem from "shirking" rather than from some government error; e.g., incorrect requirement specification or poorly trained government oversight personnel. Even if past shirking is established, it is not always easy to show that past performance is sufficiently predictive to warrant excluding a firm from competing for new business. Politics also make it difficult to exclude firms. Many firms have major constituencies in Congress; lobbyists ensure that the respective representatives know the numbers of direct and indirect jobs flowing from each procurement. On the legal side, the difficulty in firing or refusing to hire a firm is exacerbated by the legal encumbrances facing the government manager even if they have performed poorly in the past.[10] Although past performance may by law be considered when determining a contract award, most implementing procedures found within the government's many procurement agencies have severely narrowed the use of this information. Most government procurement officials are so apprehensive about using past performance in source selections that almost a dozen industry groups recently wrote a letter to Senator Sam Nunn requesting help [30]. The groups call on the government, as part of the on-going procurement reform initiatives, to make past performance a real consideration in future source selections:

> Past performance is one of the most critical factors in successful source selection. Current federal practice is lacking in uniformity and consistency and, in too many cases, is non-existent. In a procurement era increasingly characterized by complexity, high technology and developmental performance demands, an assessment of a contractor's relevant past performance is one of the strongest quality discriminators available to the federal buyer [30].

• **Award Life Cycle Software Contracts:** Another direct solution would be to eliminate the separation between development and support of software systems. Under these circumstances, a contract would be awarded to a firm to develop and then support the software. The contract identify the level of support the government would tolerate, forcing the firm to achieve a level of quality during development that would allow them to realize a profit during development. One problem with this approach is that Congress restricts the length of government contracts usually to between one and five years, depending upon the nature of development. A life cycle contract, encompassing the development and support phase, could reasonably span 5 to 15 years for many projects. Even if life cycle contracts were permitted within the next few years, it would take years of experience and data collection before one would know how to structure a contract in order to align contractor incentives with the government's overall goals.

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[10] There are multiple reviews, boards, and courts to which the firm may appeal. Unless the government can prove outright fraud, firings are extremely rare, even on programs with huge cost and schedule overruns or performance flaws.

• **Reorient Incentives Towards Software Quality:** The incentives for industry can be modified simply by restructuring the bases for their payment. There are two parts to the shift in incentives: First, cost and schedule incentives would have to be de-emphasized. Second, the immeasurability of quality requires a different path than a simple shift to quality incentives. Emphasis on quality should occur through an indirect link to something more measurable, such as Software Process Improvement (SPI), an approach that encourages contractors to embrace software development practices believed by many practitioners to be essential to developing "good software."

Software process improvement offers the means for shifting how money is spent over the life cycle of a system by making it worthwhile for firms to establish more rigorous software development processes and to increase training of development personnel. SPI consists of many activities by which firms can improve the processes, technologies, and quality of the workforce they employ to produce software systems. It is an attempt to bring engineering rigor or the discipline of science to the development of software. The end goal is higher quality software developed under conditions of more predictable cost and schedule performance. A software process consists of those processes, methods, or tools that establish the managerial and technical environment in which software products are developed, including associated products (project plans, schedules, design documents, code, test cases, user manuals, and meeting minutes are some examples) [31-32].

The Defense Department's Software Engineering Institute (SEI) spawned the SPI industry with its initial version of the Capability Maturity Model (CMM)[11] for software. The SEI and CMM were created to help the Defense Department and its industrial suppliers understand and control the plethora of acquisition problems in building very large software systems. The CMM is used as a guide, framework, or point of reference for most SPI programs. Currently, the software industry spends easily more than 100 million dollars per year on SPI activities.

The CMM is a normative collection of observable software development and management practices that are believed by many, particularly advocates of "software engineering," to produce better software. The CMM is not a validated, operational model for companies to optimize their software development processes. The model consists of five basic levels of process maturity to capture the progression from an ad hoc software process to one that is under statistical control and a stable foundation for continuous process improvement. Each maturity level is made up of a varying number of key process areas representing different facets of the software development process such as project planning, configuration management, and defect prevention. The model is organized to give contractors incentives to invest in greater levels of software maturity.

By using SPI as a proxy for software quality, software quality is being put on more equal footing with the more measurable dimensions of performance. Offering incentives for SPI can be done without much political and cultural change. However, experience using SPI as part of an incentive package is limited.

The first two solutions possess some merit in resolving the problem of acquiring quality software products; however, the government and industry's record regarding procurement reform over the last four decades, in terms of changing laws, regulations, and culture to make the processes more efficient, has been, at best, slow. Furthermore, each would require time consuming legal changes by Congress and cultural changes in the

[11] The Capability Maturity Model (CMM) is the product of decades of software development and management experience by Watts Humphrey, the Software Engineering Institute, and many current and former IBM software managers and practitioners married to the quality control principles of Crosby [33], Juran [34], and Deming [35]. The initial version of the model is detailed in [36].

government's procurement agencies. A less than perfect alternative, restructuring a firm's incentives towards software quality, may be a politically and legally feasible policy option.

4.0 A Principal-Agent Model For Government Software Procurement

There are important facts of life in software procurement. Quality is much more difficult to measure than the scheduling and budgeting aspects of performance. Quality improvement is inherently risky. The government tends to underreward investment in software quality.

The software acquisition relationship is modeled using a specialized version of Holmstrom and Milgrom's [12] principal-agent model. The specialization consists of adding a third dimension to account for SPI. The model is used to explore the conditions under which it is in the government's interest to offer an incentive for SPI.

4.1 Tension Between Quality and Timeliness: In the procurement of software systems, a tension exists between the most measurable dimension of performance, timeliness,[12] and the least measurable dimension, quality. Government contracts typically incorporate measures of timeliness, but little or nothing on measures of software quality.

Arrow [37] argued theoretically that there is a tendency to underinvest in risky tasks. From an empirical perspective, Myers' [17] indicated that effort on software quality is a risky proposition and that firms typically choose to emphasize timeliness, underinvesting in quality. The exchange of quality for timeliness takes the form of departures from good software development practices. Some examples are:

- prototyping is scratched from the plan even though the customer has little understanding of what should constitute the core set of initial requirements,
- software design is completed and programming initiated before important requirements have stabilized,
- significant programming is completed before interfaces between the system's main components have been defined, and
- the testing program is collapsed into a single system testing phase.

These practices, each of which favorably affects immediate schedule and budget constraints, will usually lower the quality of the software produced.

4.2 Specializing the Holmstrom and Milgrom Model: Holmstrom and Milgrom (H&M) deviate from traditional principal-agent models in that they consider situations where the principal desires the agent to perform a single, multi-faceted task [12]. Their model is a good framework for introducing observables and conducive to studying parameters with varying degrees of measurability (quality versus timeliness), including parameters that cannot be measured at all [12]. The linear incentive structure of their model appears to be a good approximation to government software contracting, where contractors are typically paid for the accomplishment of each of the many decomposed tasks that comprise the total procurement contract. The key assumptions of the H&M model are: 1) risk adverse contractor, 2) risk neutral government customer, and 3) effort is not observed directly by the government, but a signal related to effort is observed. Using a very general model, they show that when an contractor performs a multi-faceted task, linear incentive payments optimally balance the trade off between providing incentives versus not putting too much risk on the contractor.

[12] For simplicity, we use "timeliness" as a single variable denoting all of the easily measurable dimensions of performance, most notably cost and schedule parameters. Including two or more measurable dimensions would complicate the modeling needlessly. From a pragmatic point of view, this simplification is appropriate since cost and schedule performance are strongly correlated in software procurements.

- **Holmstrom and Milgrom Model**: Define the following:

t = vector containing the contractor's effort selections for each attribute important to the government

Y = is a vector of normally distributed signals the government observes for each of the contractor's effort selections for each attribute ($\mu(\mathbf{t}) + \varepsilon$, where $\varepsilon \sim N[0, \Sigma]$)

W(**Y**) = contractor's wages based upon signals or metrics, **Y**, of the contractor's efforts

a = vector containing the incentives provided by the government for each attribute

b = scalar indicating the sharing rule allocating the joint benefits between the government and contractor

r = scalar measure of the degree of the contractor's risk aversion

B(**t**) = benefits that accrue solely to the government from the contractor's efforts **t**. B(**t**) is assumed to be concave in its arguments.

C(**t**) = costs the contractor incurs based upon its effort selections. C(**t**) is assumed to be strictly convex in its arguments.

The contractor examines the compensation contract, W(**Y**), the associated costs, C(**t**), for expending effort, and selects an effort allocation to maximize his profit:

$$E\left[-e^{-rW(\mathbf{Y})}\right] - C(\mathbf{t}) \qquad \textbf{(1a)}$$

All benefits, B(**t**), accrue entirely to the principal; thus, she chooses W(**Y**) (i.e., a function) in order to maximize her returns:

$$E\left[B(\mathbf{t}^*) - W(\mathbf{Y})\right] \qquad \textbf{(1b)}$$

where $\mathbf{t}^*$ is the solution to (1a) and, consequently, dependent upon W(**Y**).

From H&M, we know the contractor's wages depend upon the incentives, signals observed by the government, and a scalar allocating the total certainty equivalent between the two parties:

$$W(\mathbf{Y}) = \alpha^T \mathbf{Y} + \beta \qquad (2)$$

Consequently, [1a & 1b] have the same solution as that found by solving for the total certainty equivalent (joint surplus):

$$\max_{\alpha,t} \; B(t) - C(t) - \frac{1}{2} r\alpha^T \Sigma \alpha \qquad (3)$$

subject to the following constraint:

$$\mathbf{t} \text{ maximizes } \alpha^T \mu(\mathbf{t}) - C(\mathbf{t}) \qquad (4)$$

where $\alpha^T\Sigma\alpha$ is the variance of the agent's wages under the linear incentive structure.

- **An Incentive For Software Process Improvement (SPI):** The specialization of the H&M model centers on the government's desire that the contractor expend effort on SPI because, as will be shown, SPI has an overall positive effect on software quality. We now make some important assumptions for modeling government software procurement: first, this problem involves three attributes: timeliness, quality, and SPI, where the effort expended on each activity is represented by t_1, t_2, and t_3, respectively; second, software quality is difficult to measure and most organizations perform little or no quality measurement [16, 38]; and third, the government derives no direct benefit from SPI. The associated incentives for timeliness, quality, and SPI are α_1, α_2, and α_3, respectively.

The government derives no direct benefit from SPI. The single most important assumption in this model is that B_3, or the partial derivative of the benefit function with respect to t_3, equals 0. Nevertheless, the government desires the contractor to expend effort on SPI because they know it generally improves quality and timeliness. The government can only derive direct benefit from contractor effort expended on timeliness and quality. Thus, we show that even though the government does not benefit

directly from SPI, the government will still find it desirable to reward efforts for SPI.

The other important procurement-related assumption is the difficulty of measuring software quality in a procurement. It is difficult to measure relative to the other dimensions of our model of government software procurement. To capture this phenomenon in our model, we assume the variance of measuring software quality is significantly larger than the variances for measuring timeliness and SPI.

Using the above assumptions, we now solve (3) subject to (4) to arrive at the optimal incentive for SPI. A complete derivation of the incentive for SPI is provided in [39].

5.0 Incentives for SPI

We now explore the conditions under which the government should pay a contractor an incentive for SPI, an activity for which the government derives no direct benefit. The government faces a dilemma analogous to the private market failure faced by insurers. Greenwald and Stiglitz showed that commodities that decrease the frequency and size of insured losses should be subsidized, including the payment of a subsidy by the government, to improve overall welfare [40]. SPI is just such a commodity, helping an organization to improve its processes and product quality which should, in turn, improve measures of timeliness.

Recent experiences with SPI provide strong evidence that as the effort expended on SPI increases, the marginal costs for timeliness and quality decrease. What is not clear is whether timeliness is affected directly by SPI or as a result of improved quality.[13] Dion [41] has provided impressive quantifiable evidence of a near 700 percent return on investment and better schedule performance from SPI activities by examining the counterfactual: "What if the organization had not done SPI?" Dion's experiences at Raytheon along with the lessons learned from other SPI efforts provide strong emerging evidence that SPI improves software quality and measures of timeliness [22, 36, and 42-50].

Additionally, Besselman and Rifkin [38] used SPI results from 51 organizational evaluations to find that organizations with their operations organized around a product line possess greater software process maturity. The more mature organizations possess a greater incentive to pursue SPI. They are better able to internalize the costs of SPI and derive benefits over the life cycle of their products as a result of their product line focus. The evidence is that increasing effort on SPI lowers the marginal costs of software quality.

The incentive for SPI is now examined under a variety of measurability conditions for timeliness, software quality, and SPI.

a) How does the incentive for SPI vary with changes in the ability to measure timeliness and SPI? This is a difficult relationship to solve analytically, so we simulated the this relationship using the derived optimal incentive for SPI. Figure 1 shows the simulation results.

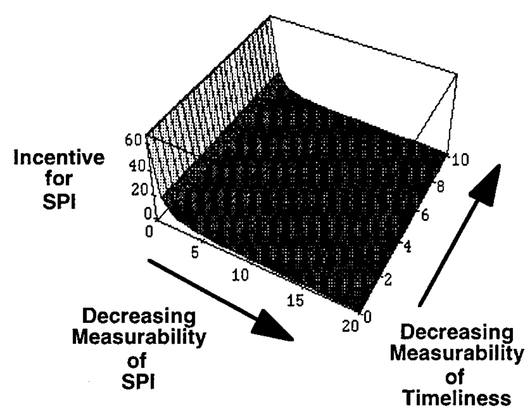

Figure 1: Change in the magnitude of the incentive for SPI with changes in the measurability of timeliness and SPI.

The simulation reveals that the incentive for SPI is not dependent upon the measurability

13Improved quality may affect timeliness by causing the respective firm to spend less time on testing and reworking activities.

of timeliness. As SPI itself becomes more difficult to measure, the incentive for SPI approaches zero.

The measurability of SPI dictates the magnitude of the incentive for SPI. The issue of effectiveness centers on the need for a reliable method for measuring SPI in an organization, including competent government oversight personnel for effectively interpreting and using the results. At this point, there is not an extensive and rigorous body of evidence telling us to what extent measured SPI predicts quality in software outcomes. Clearly, pilot SPI programs should be designed to validate the relationship between measured software process characteristics and software outcomes, and should experiment with a variety of measurement approaches from surveys to the current practice of on-site evaluation teams.

b) How does the incentive for SPI vary with the measurability of software quality? In this case, we relax our earlier assumption that software quality is difficult to measure. This relationship is captured in Figure 2.

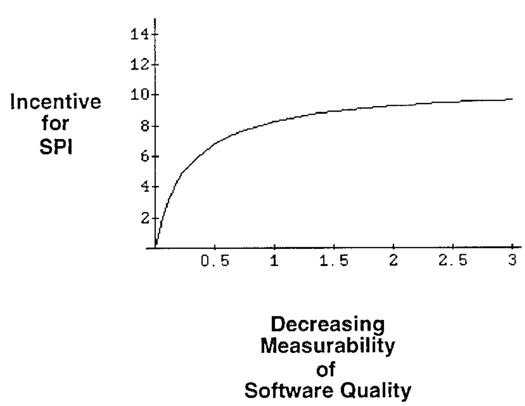

Figure 2: Change in the incentive for SPI with changes in the measurability of software quality.

As software quality becomes more measurable, the incentive for SPI, should be decreased. Again, the measurability for timeliness also had no effect on this simulation.

c) How does the incentive for SPI vary with changes in the measurability of software quality and SPI? Figure 3 captures this relationship. Unlike the finding from Figure 2, the incentive for SPI is affected by changes in its measurability. As SPI becomes more measurable and software quality becomes immeasurable, one would want to offer a greater incentive for SPI. As expected, when SPI becomes immeasurable, one would not offer an incentive, regardless of the measurability of software quality.

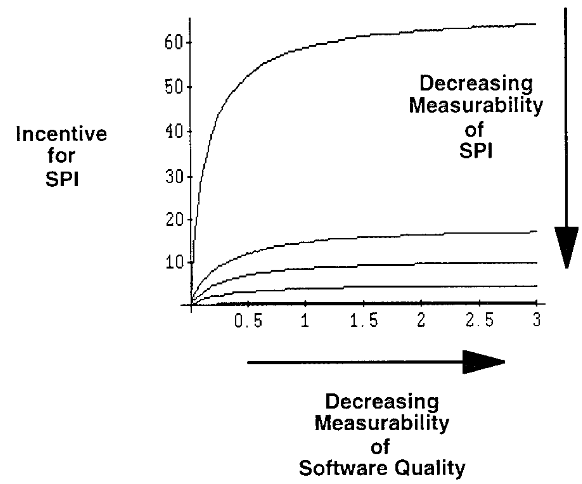

Figure 3: Change in the incentive for SPI with changes in the measurability of software quality and SPI.

We can also show that increasing effort on software quality results from increasing the incentive for SPI (see [39] for a formal proof). Thus, if the incentive for SPI increases, so does the investment in quality, and hence, so does the average quality of the software.

The intuition behind our results is straightforward. By providing incentives for SPI, the government indirectly encourages the software developer to increase effort on improving quality. As our results have shown, the greater the reduction in marginal cost of quality from SPI, the bigger the effect of encouraging SPI on the agent's efforts to

quality, and hence the greater should be the government incentive for SPI. Our results also show that the greater the precision in measuring SPI, the greater should be the government's incentives for SPI. Thus, SPI works if it lowers the marginal cost of improving quality and if it can be measured more precisely than software quality can be measured.

6.0 Recommendations for Reform

Our recommendations are drawn from the findings yielded by the model. First, the government should consider offering incentives for SPI in software intensive procurements, particularly those procurements where contractors are being brought on for short periods of time and in a time and materials contract capacity. Second, the government should diminish the emphasis on cost and schedule incentives to accommodate SPI. Third, when a government program office chooses this course of action, they need to ensure they are using reliable evaluation techniques and trained evaluation teams. Our findings clearly indicate that the quality of the government's software management personnel affects whether it is practical to offer an incentive for SPI.

The main attraction of our recommendations is that the current body of procurement rules and regulations can easily accommodate them. To include incentives for SPI in software intensive procurements requires no legal intervention from the Congress or the various procurement agencies of government. The principal change from SPI is a restructuring of the payment pools in the contracts written by government managers.
One government acquisition organization, the U.S. Air Force, has already begun experimenting with SPI incentives and several other organizations are considering them. SPI's political feasibility is a main attraction. We hold no illusions that far reaching reforms, two of which we discussed in Section 3.0, will take place anytime soon, so we have focused on feasibility.

7.0 Conclusions

This paper modeled the relationship between timeliness, software quality, and SPI in software procurements to understand the conditions under which the government should offer incentives for SPI. The key assumptions in modeling were that SPI will enhance the quality of a product and result in better cost and schedule performance all the while the government derives no direct benefit from SPI. More specifically, the justification for the government's offering incentives for firms to engage in SPI activities hinges on whether increases in effort on SPI decreases the marginal cost of software quality and on whether the government will be able to measure SPI effectively. Several citations, largely consisting of anecdotal findings and small sector studies, were provided indicating that increases in effort for SPI decreases the marginal cost of software quality. There is not, to our knowledge, any rigorous, industry-wide empirical evidence regarding this relationship.

Empirical work is badly needed. How does SPI affect the production function for software? Does SPI help or hinder the development of better quality software? Does it depend on organization style or size or type of software being developed?

The government should experiment with SPI on several new procurements involving firms at all levels of software process maturity. The theoretical work in this paper sets priorities for the empirical work: How does an increase in effort for SPI affect the marginal cost of quality and timeliness? What are the magnitudes of the effects? There should be a systematic, industry-wide study of the effect of SPI on timeliness and quality.

Even though the government derives no direct benefit from SPI, the government may be justified in offering SPI incentives to firms. The government systematically underinvests in quality while acquiring software. This underinvestment significantly delays and increases the life-cycle costs of software. The difficulties in measuring software quality and incorporating measures of software quality into contractual relationships is a primary contributor to the government's underinvestment in software

quality. SPI may effectively serve to improve software quality. Thus, organizations that undertake SPI programs may be expected, on average, to produce higher quality software. There are measurable characteristics of software development organizations that are widely believed to be associated with producing better quality software. These associations must be examined empirically.

However effective SPI is, it can solve only part of the government's software acquisition problems. The government still needs to address other fundamental flaws in the way it contracts for software to reduce costs and time to development while increasing quality. The most obvious flaws are one to five-year contract increments and the separation of the development and maintenance phases, precluding the government from taking a life-cycle perspective in software acquisition.

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Exploiting The Synergism Between Product Line-Focus and Software Maturity

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Abstract

Using emerging evidence of the benefits of software process improvement, we present a theory for why the software development community is witnessing differential results from its software process improvement efforts. Our theory predicts that firms organized around product lines are more likely to possess higher levels of maturity. Using the results of 51 software evaluations and assessments, a statistical test fails to reject the theory. Our findings lead us to recommend that the government should offer incentives for software process improvement in software intensive procurements, embrace, where appropriate, a product-line approach to procurement, and refrain from placing software quality requirements in contracts.

Introduction: There is a great deal of uncertainty surrounding the actions a firm must take to improve its software processes and realize a positive return-on-investment from software process improvement activities. The landscape is replete with firms that have learned that successful software process improvement does not merely consist of performing the practices in the Capability Maturity Model (CMM) for Software [1]. Issues of leadership, business strategy, software technology, market forces, relationships and leverage with the customer, and a plethora of human and organizational issues appear to play a role in how successful a firm is at improving its software processes and, ultimately, its financial position.

This paper provides insights into why some firms are leaving the majority behind as they mature organizationally and reap substantial benefits from what they regard as their software process improvement activities. These insights deserve careful consideration as the government attempts to craft software procurement reforms to take us into the next Century.

Using findings from government-led software capability evaluations and firm-sponsored software process assessments collected over the last four years, we find that higher maturity organizations are either developing commercial products[1] or have their government procurements structured around a development that can be characterized as a product line. Embodied in the product line focus is significant reuse of software components and architectures. As an example, so great are the benefits and intense is the competition in the international air traffic control system market, that a handful of high maturity firms have seen their development costs drop from the many hundreds of million of dollars to the tens of millions of dollars per system in the span of five years.

This paper examines data we have collected over the last few years and offers a theory for why this focus on product lines may be occurring. At this point, we cannot determine whether software process maturity causes an organization to focus development around product lines or a business strategy of product line focus motivates stronger efforts at software process improvement. We do believe, however, that economics is the motivator for both strategies, so we explored the economics of simple incentive contracts with extensions to accommodate the effects of software process improvement (SPI).

An analysis of the economics reveals that companies are able to develop stronger process improvement programs because of their ability to amortize their process improvement costs over a larger product base

[1]By commercial we mean non-government sector, not necessarily the "shrink wrap" software sector, Though the findings are equally applicable to the shrink wrap developers, they are not heavily represented in our sample of firms.

and derive life cycle benefits. These organizations realize these benefits because of today's iterative software development processes, where multiple releases are making individual, typically government projects more similar to commercial products.

This paper will open with a brief description of the problem domain and why it is an important public policy issue. We then examine the field survey data, including a brief discussion of the data's limitations. A model of government procurement is then presented using a simple incentive contract. The model is an extension of the simple incentive contract used by economists studying defense procurement. This model is augmented by introducing variables to account for how SPI affects the procurement equation. We then discuss each of the variables in light of current procurement realities and our current knowledge of SPI. The paper closes with several public policy recommendations.

Importance as a Public Policy Issue: With nearly all of the government software contractors and most commercial contractors engaged to some degree in a SPI program, an enormous amount of money is being spent by government and industry on SPI. Even Microsoft, the firm that apparently used to disdain process [2], is now heavily involved in its own form of process improvement within one product line.[2] The specific motives for each company pursuing SPI vary:

- Some organizations are engaged in this activity because they want to continue to reap the productivity benefits they have been experiencing
- Some are continuing their genuine efforts despite achieving mixed results
- Some are finally initiating programs in order to emulate some of their more successful competitors
- Some continue to watch closely, experiment, and "hire the best people"
- Some lay claim to "inventing" process in order to further differentiate themselves in the marketplace
- Some do not really believe in SPI, but put forth a modicum of effort in order to fill a square.

The fact remains, however, that if you examine nothing more than the number of people attending process improvement conferences and workshops, then easily in excess of 100 million dollars a year is spent on labor costs alone for SPI. If you factor in the actions taken to facilitate SPI, then many hundreds of millions of dollars are spent each year on SPI, making it an extremely important phenomenon to understand.[3]

One motive, filling the square, has come about in the government sector because software capability evaluations[4] are occasionally used when the government is looking for a developer of a system and they are considering minimum software process maturity levels as a basis for awarding the contract. While the government continues to evolve a policy, there exists little theoretical or empirical understanding other than that offered by Arora *et al.* [3], Flowe and Thordahl [4], Herbsleb *et al.* [5], and Dion [6

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[2]Microsoft's new-found affinity for the software process was presented in a talk by MIT historian of technology Michael Cusumano at Carnegie Mellon University on January 16, 1995. His talk revealed that within the last five years Microsoft had "discovered" the value of process and iterative software development as their products grew in size, a hard lesson countless other software developers have learned over the last three decades.

[3]This is a rather conservative estimate. The most recent Software Engineering Process Group National Meeting, a symposium for software process improvement practitioners, had more than 1000 people in attendance. If you assume the average person's salary, benefits, and workplace expenses amount to $120 thousand dollars (conservative), then one can immediately see the scale of expenditures on software process improvement. Once all labor costs and various process change costs are factored in, $100 million is an extremely conservative estimate.

[4]Software capability evaluations are procurement-related audits performed by the government to measure the software process maturity of a contractor. They are used in source selections and on-going software intensive procurements. Software process assessments are an analogous technique used by industry to either measure themselves or with the help of an outside consultant.

and 7] for how SPI affects the economics of a software product and of a firm. These anecdotal findings are not easily comparable and consist of reasonable, but possibly subjective assessments of cost savings and productivity and quality improvements. No rigorous work has yet been done relating software process maturity levels to procurement outcomes.

With regard to the government sector, understanding the economics is important for any SPI policy because the government should be in a position when mandating practices of understanding the financial consequences to industry and government. It is the mission of government, working with industry, to arrive at an effective policy for motivating software process improvement. Perhaps Pope John XXIII spoke more eloquently of this important relationship:

> There exists an intrinsic connection between the common good on the one hand and the structure and function of public authority on the other. The moral order, which needs public authority in order to promote the common good in human society, requires also that the authority be effective in attaining that end.

This paper offers a theory delineating the costs and benefits of SPI coupled with a product line focus for both parties in government software procurements. Armed with this information, government and industry should be better able to create a policy fair to both parties.

Field Survey Data: A software capability evaluation at TRW in 1993 provided the impetus to initiate this study and collect data. It was during that time that one of the authors saw first-hand Walker Royce's, formerly of TRW, efforts at building a product line around one of the developments he managed. The process maturity differences between the "product line" and "other" business prompted our study.

The field survey data consists of 37 government-led software capability evaluations and 14 firm-sponsored software process assessments. For consistency, the data was drawn from only teams that were led or trained by one of the authors. None of the data in our sample are drawn from self-assessments by a firm.[5] Each team leader was polled for information about each firm: nature of products being developed, number of projects, customer-base, evidence of product line focus, and maturity level.

Aside from each firm's maturity level, the critical piece of information sought was whether the firm had the ability to control the life cycle of their products. Did the firm engage in one- to five-year contracts with the government where there is a contractual partition between development and maintenance or was the firm servicing a commercial customer where development consisted of multiple releases built upon a core architecture? If the firm had a product line focus, then the firm controlled the life cycle of their products; i.e., they had the ability to derive life cycle benefits from greater attention to quality during development. If the firm developed commercial products, then they either controlled or had the ability to control their life cycle. If the firm relied solely on government contracts, possessed little or no evidence of reuse, possessed a wide variation of project types, or lacked a product line focus, then we determined that they did not have the ability to derive benefit over the life cycle of their products. Due to the expense and time required to collect this kind of data, we relied on the judgment of each team leader in making the determination of whether a firm had control over the life cycle of their products.

The data is summarized in a contingency table found in Table 1, where it is sorted by maturity levels and whether an organization controlled the life cycle of their products. A "+" attached to the maturity levels indicates the organization was strong at that level. No maturity level scores extend beyond 3+ because the teams did not spend the time to reliably examine practices beyond level 3.

[5]This an important point, for a problem pervasive in the SPI community is the maturity level differences between firm-led assessments and government-led evaluations. See [8] for more discussion.

Much of Table 1 consists of process maturity information on a sample of companies engaged in the development of software systems for the government and industry (some drawn from [8]). The sample is biased towards firms developing command and control systems for the government. Some of the companies developing government systems also develop commercial products. A few organizations are reflected more than once to account for different teams evaluating or assessing the same site, usually with different project selection and at a different point in time. There are some limitations to the data beyond what has already been mentioned:

- The data points (organizations) are not a random sample. Each organization was, for the most part, an early adopter of SPI.
- Some of the assessment data points represent projects.
- Multiple organization and project sizes are represented.
- The data points were collected over a three-year period.

Maturity Levels vs. Control of Life Cycle		
Maturity Levels	Control of Life Cycle	
	Yes	No
1	1	16
1+	5	4
2	10	2
2+	2	0
3	7	0
3+	4	0
	29	22

Table 1: Field Survey Data From 51 Evaluations and Assessments

Simple Incentive Contracts: In this paper, the government engages in a contract with a firm to develop a software system. This contract is really a risk sharing relationship important to both parties: the government, in its search for the perfect incentive contract motivating a contractor to meet its schedule while making a fair profit, appears to oscillate between fixed-price contracts (contractor bears all risk) and cost-plus contracts (government bears all risk).[6]

Since Peck and Scherer [10] performed their pioneering economic analysis on defense procurement, many economists have revisited this problem every few years. Scherer [11] introduced the basic model of a firm's profit function and the government's associated cost function:

$$\Pi_f = \Pi_t + a(C_t - C_a) \qquad (1)$$

where Π_f is the firm's profit, Π_t is the firm's target or negotiated profit, "a" is a sharing parameter between the government and a firm, C_t is the target or negotiated cost of the system, and C_a is the actual cost of the acquisition. This simple incentive contract represents some of the contract types encountered in government procurements. When a=1, the contract type is firm-fixed price. When a=0, the contract type is cost-plus fixed fee. When "a" is allowed to vary between 0 and 1, it is viewed as a simple incentive contract. Much of the research over the years has been on determining what is the optimal value "a" for the government and each firm [See, for example, 11-15]. Unfortunately, the findings have been inconclusive and sometimes contradictory.

Extending The Simple Model To Account For SPI: We now explore how, if at all, does SPI affect this equation. Dion [1993: 28] has provided impressive quantifiable evidence of near 800 percent return on investment and better schedule performance from SPI activities by examining the counterfactual: what if we had not done SPI? Dion's experiences at Raytheon, along with our experiences and the lessons learned from other SPI efforts, offer a number of financial opportunities [6, 7, and

[6]This oscillation appears to have been going on since the 1950s when Peck and Scherer [1962] first documented it. Roughly, the excess profits in the defense industry during the 50's and 70's from cost-plus contracts were followed by periods of fixed-price contracts in the 60's and 80's, respectively. This practice appears to have saddled many defense contractors with heavy debt and unprofitable programs in the 80's [9]. Despite the wealth of research in the area of efficient incentive contracts, the government has oscillated back to cost-plus contracts for most developments in the 90's.

16-19] from which one may extend equation (1):

- Firm's substantiated software process improvements bring prestige and new business to the firm, P;
- Firm's process improvement activities enhance current operations, improving immediate cost and schedule performance, R;
- Firm's process improvement activities cause dissemination of lessons learned across the organization (spillover), resulting in higher profits, S; and
- Firm's process improvement activities result in life cycle cost savings from defect reduction and a better system architecture, L.

With these new variables; prestige, P; immediate cost savings, R; spillover, S; and life cycle savings, L; the simple incentive contract model becomes as follows:

$$\Pi_f = \Pi_t + a(C_t - (C_a - R)) + P + S \qquad (2)$$

This model provides a simple description for discussing and analyzing the problem domain. Conspicuously missing from the new simple incentive contract is the life cycle savings variable, L. This purposeful omission is discussed subsequent to the included variables. We concede that the new variables are interdependent to some degree. Also, this is probably not an exhaustive accounting of all variables. One could certainly extend or refine the model to account for behavioral aspects of SPI; e.g., movement of people across projects or organizational boundaries, or the notion that SPI creates value in people. These we have left for future research.

Each of the new variables added to the equation as a result of SPI appear compelling within the confines of a specific acquisition, but can we generalize their sign or magnitude across all procurements? We now look at each variable in isolation.

- **Prestige:** The first variable, P, prestige or "new business," appears at first glance to be a tangible consideration. There have been several high profile procurements that have made maturity levels a major determinant and some government procurement organizations have even called for minimum maturity levels in source selections. However, there really has not been a systematic effort by the government to base awards on maturity levels and/or past performance.[7] Procurement officials appear reluctant to use measures that fall under the rubric of past performance [3]. Even if we are overnight to make past performance a major consideration, we have the messy problem of determining who is responsible for procurement outcomes. How do we separate firm behavior and the government's dysfunctional oversight practices [20]?

Evaluating SPI in the context of a source selection is an example of past performance being used. Until there is some evidence the government is consistently using past performance in source selections and a few of the more mature organizations can point to a disproportionate number of source selection victories, we have to assume that prestige is zero in nearly every case.[8]

Complicating the introduction of the prestige variable is the use of software process maturity levels by many firms as a marketing

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[7]The problem may be even more serious than meets the eye. As recently as 1994, one experienced government procurement agency awarded an estimated $20 million dollar software contract (Ada development with a potential $100+ million procurement tail) to a firm with no experience, no staff hired at contract award, and with a program manager that did not know what configuration management meant after announcing a 12-month schedule slip a mere seven months after contract award.

[8]Some exceptions to this may be emerging: some divisions of Raytheon, Hughes, and possibly a couple others. They have taken a very public stance on their maturity(many publications), and judging from some of their contract awards, they appear to be able to back it up. Also, their visible position undoubtedly has some effect on the very human-dependent source selection process.

tool. Many firms are publicly reporting maturity level 3 and 4 status despite government-led or joint evaluations (whose results are not published) to the contrary. As recently as within the last quarter, one of the largest Software Process Improvement Network (SPIN) groups hosted a speaker from "A Level-Three Company" that had two evaluations performed within the last six months that found it to be level 1, one of which was a joint government/firm team.

The next new variable, R, immediate cost savings, is the funding saved on the respective program during the development as a result of SPI. It is subject to the sharing variable, "a," because cost savings within an acquisition are usually shared with the government. This variable is often believed to be the only result of SPI. All indications are that it quickly becomes positive after the most rudimentary process improvements.

The last variable, S, spillover, is positive and a fundamental part of any improvement effort. One of the tenets of SPI is benchmarking and piloting in order to learn more and perfect a particular process innovation. The "spillover" variable enters anytime a an organization begins to act on a successful pilot; i.e., disseminate the respective practice throughout its other relevant projects. Both R and S need to be tracked to get a better indication for SPI's real contribution. However, all of the variables discussed so far pale in importance to the next variable, life cycle cost savings.

The life cycle cost savings variable, L, is the "action" or heart of our thesis: those organizations building many unrelated systems for customers on support or time and materials contracts normally do not reap the life cycle benefits of SPI. Those organizations are typically in a state of change as their contracts are frequently modified and their personnel shift around (including sometimes leaving the company) to accommodate the changes. Only those contractors building commercial products, or government contractors that have organized their developments around a core product line, derive the life cycle benefits. Consequently, only they can add L to their equation. The less fortunate contractors may put forth the effort, but the customer (government) will ultimately derive the benefits.

We represent the relationship between benefits from SPI and SPI effort in Figure 1. Two benefit functions are used to convey the differences in returns from SPI based on whether a firm has instituted a product line focus in their organization.

Arbitrary functions are chosen for how benefits of SPI change as SPI effort increases. The two benefit functions are concave overall, but, since it is assumed that some effort must be expended before benefits begin to accrue to SPI, the benefit functions are initially convex. As benefits begin to accrue, the benefit functions take on a concave appearance in order to capture the diminishing returns that an organization eventually realizes. In other words, a point is reached where improving a process requires increasingly greater effort to squeeze out further benefits. Benefit function "A" represents the potential benefits a development organization may reap through successful SPI: better cost and schedule performance through a higher quality process and product for the respective project during development. Benefit function "B" is nearly a vertical shift of "A" to capture the additional life cycle benefits only some organizations realize, those that have organized around product lines.

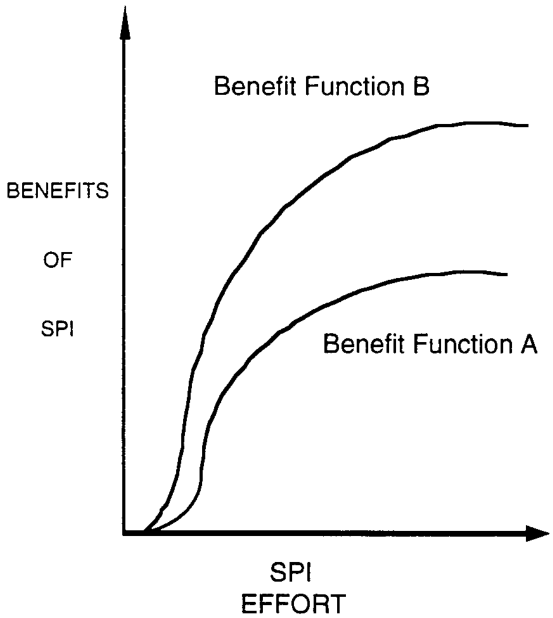

Figure 1: Benefits Versus SPI Effort

First, these product-line oriented organizations are able to derive benefits over the life cycle of their product lines by paying stricter attention to quality during development. Naturally it costs more in terms of effort to take a process improvement program to this level, but it is not nearly as costly as the benefits one derives from such efforts. Given the abundance of data detailing the benefits of removing errors during development versus their removal cost during maintenance, this increase in benefits is also nearly exponential [Weller, 1993; Kajihara et al, 1993; Dion, 1993; Russell, 1991; Mays et al, 1990; and Boehm, 1987].

Second, as part of their emphasis on product lines, these firms are deriving significant benefit from reusing software and architectures. The aforementioned high maturity firms building air traffic control systems are no longer building systems based entirely on custom software. They are building new systems based upon an evolving system baseline. Over time, as more and more customers take delivery of the latest system version, they are receiving a higher quality core system that employs custom software only in those functional areas where tailoring is required to meet the unique requirements.

Third, the ability to derive life cycle savings causes a firm to make completely different effort selections when it comes to SPI. The effort selections will typically be greater for a firm that has organized around product lines. Consequently, the firm's returns from prestige, P, internal savings, R, and spillover, S, should be substantially greater than a firm with no concern for life cycle savings.

The economic incentives are such that the potential returns from SPI are much greater for commercial or "product line" companies.[9] Given these conditions, we must hypothesize the following:

> **Those organizations developing commercial software or a supplier who has taken a "product line" approach to their developments are more likely to possess higher process maturity levels given they have initiated programs of improvement.**

To test our hypothesis, we performed a chi-square test of the contingency Table 1. We should be able to reject our hypothesis if there are no significant differences in maturity levels between the two types of firms identified in Table 1. The test revealed significant differences in maturity levels for those firms that had the ability to derive benefit from SPI over the life cycle of their products; i.e., firms organized around product lines were found to possess higher

[9]It has been alleged elsewhere in the community that commercial companies are lagging behind the defense contractors in SPI. We do not address the veracity of this allegation, as it is not critical for our conclusions. Nevertheless, defense contractors have had significantly more opportunities for exposure to SPI and certainly "encouragement" from the government. Technological change takes time. We merely argue that commercial companies and those government contractors with their developments organized around product lines are ultimately the greatest beneficiaries of SPI.

levels of software process maturity (χ^2 = 38.9, $p < .0001$). This finding lends significant support to our hypothesis.

Discussion: Simply put, the government desires that their contractors put forth the effort in SPI needed to maximize the government's returns from SPI; i.e., the government needs all contractors to be concerned about life cycle cost savings, not just the contractors developing systems where a product line focus is a natural strategic decision for a firm to make. Unfortunately, for a variety of reasons, not all firms participating in government procurement may derive benefits over the life cycle of a contract. The short-term duration for many software contracts, contractual separation of development and maintenance, use of time and materials contracts, and the inability of the government to effectively use past performance [21], even when firms have done a great job, provides perverse incentives for many of these firms. They have a difficult time justifying effort on SPI, for the returns will accrue entirely to their customer, but the firm will have to absorb the cost internally.

Figure 2 repeats Figure 1 but adds some additional lines to illustrate the change in benefits from a change in effort and focus on product lines by an hypothetical firm. The figure identifies two new variables: dB and dE, change in benefits from and change in effort expended on SPI, respectively.

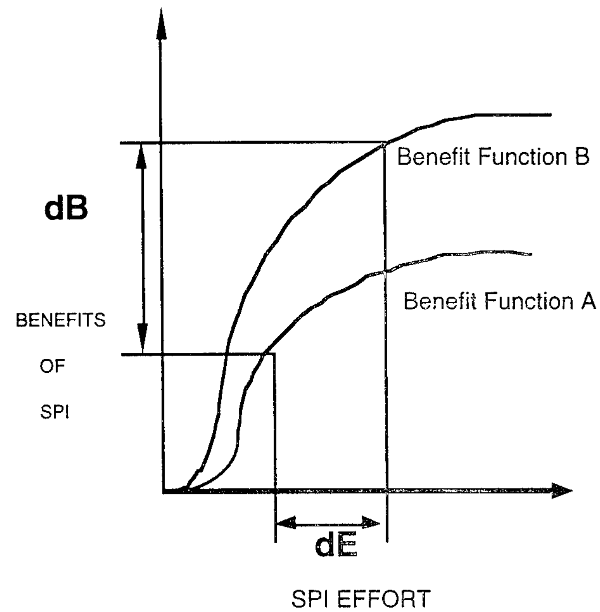

Figure 2: Change in Benefits Versus SPI Effort

Similarly, we can represent the change in costs to the firm as a result of increased effort on SPI. A firm must invest in order to train its workforce, study and change its processes, and produce higher quality software. The relationship between a change in SPI effort and increased cost is captured in Figure 3. Another new variable, dC, is used in Figure 3 to represent the change in cost associated with the same change in effort depicted in Figure 2. The cost function is convex. Whether it is linear or nonlinear does not affect the analysis.

Based upon emerging SPI evidence [3-7 and 16-18] and the existing literature on the life cycle benefits of eliminating defects as early as possible [21-25], we know the benefits from SPI are significantly greater than the associated costs; i.e., if an organization augments its SPI efforts toward benefit function B and stops its SPI efforts when returns begin to diminish (when benefit function B goes flat), then dB >> dC. From the government customer's perspective, as their contractor expends dC more effort on SPI, the government will derive dB dollars in benefits through life cycle cost saving. If the

contracting firm is organized around a product line, it will also derive potentially greater benefits as it has now either established a high quality baseline from which to build future systems for future customers or has improved upon an existing system and delivered it to its government customer at a far reduced cost from that which any other firm could have delivered at if it had built the system from scratch. The benefits to both parties in the contract far exceed the costs. The problem for the government is how to motivate all contractors to perform in a manner consistent with benefit function B, including those that presently engage in contracts where they are not capable of deriving life cycle benefits from SPI.

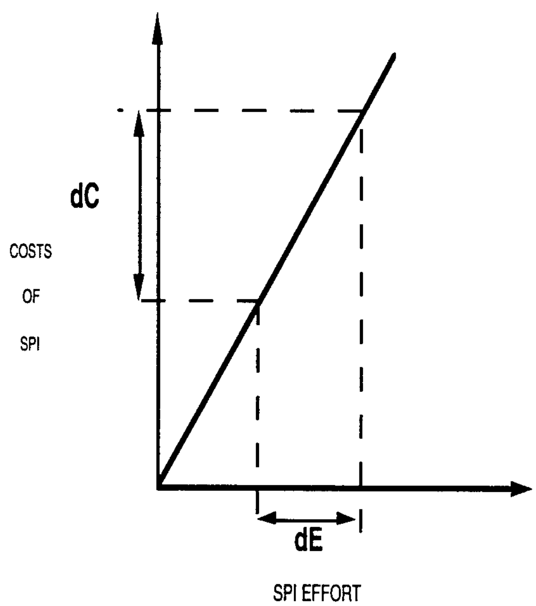

Figure 3: Change in Costs Versus SPI Effort

Public Policy Recommendations: In translating our findings into recommendations, we constrained ourselves by feasibility. That is, we sought reforms that could be feasibly carried out with no congressional intervention. We want to give the entrepreneurs toiling in the program offices some initiatives they could easily carry out with minimal effort to achieve maximum gain.

There are two parts to the remedy that will improve the current situation for the government: motivate SPI and eliminate dysfunctional incentives. These two parts translate into at least four actions government and industry should embrace to maximize benefits to all parties from SPI:

- Where appropriate provide incentives for SPI in government procurements
- Decrease emphasis on cost and schedule incentives
- Where appropriate, the government should embrace a product-line approach to procurement
- Do not initiate incentives for defect metric targets

• **Incentives For SPI:** The government wants the contractor to engage in SPI in a manner consistent with the benefits produced in benefit function B. Not all contractors have the economic incentives to perform at that level. Even when contractors have their developments oriented around a product line, there is no guarantee that they will perform at a level to maximize the government's life cycle benefits from a high quality development process on a particular acquisition. Despite a contractor's best intentions, there will be circumstances where software process performance abates or regresses. Consequently, as part of the remedy for this situation, the government should provide an economic incentive to the affected contractors equal to an estimate of dC. Even when paying this additional sum, assuming the contractor already has a sound SPI program, this is a win-win situation for the government and contractor: government benefits from greater life cycle savings and contractor enjoys more predictable product development cycle and spillover benefits.

• **Decrease Emphasis on Cost and Schedule Incentives:** Another part of the remedy addresses the other incentives typically found in government procurements: cost and schedule or "timeliness" incentives. There is a tension in all software developments between timeliness and quality. This tension arises because the government is quite good at requiring and then reviewing

timeliness metrics[10], but it is a rare occurrence when the government places software quality measures on contract in the form of an incentive. Most contractors are very much aware of this tension. To the detriment of quality, they usually pay more attention to issues of timeliness. Consequently, we recommend decreased emphasis on timeliness incentives, including the government requiring timeliness metrics, in software intensive procurements. Instead, government and industry should work towards a policy where a minimum maturity level is one of the bases for contract award and economic incentives for SPI are part of the contract. In other words, the government should seek to do business with contractors that collect and use their own internal timeliness metrics as a normal business practice. The government will then get the benefits derived from effective use of metrics without the dysfunctional baggage brought on by the side-effects of contractually requiring certain contractor behaviors.

• **Government Product-Line Procurement**: The oblique message of our product-line finding is that the approach also makes sense for the government. In various application domains, the government repeatedly buys multiple versions of very similar systems comprised of custom made software from many different firms. Not only may this be fiscally irresponsible, but it makes no sense since in many domains much of the software functionality is very similar across systems. This is particularly true for such domains as payroll, management information, communication, command and control, and simulator systems.

The U.S. Air Force has been trying for nearly three years to institute a product line focus for the development of command centers and their ancillary functions. Developed by the Air Force's Robert Kent, the Portable, Reusable, Integrable Software Modules (PRISM) program uses two high software maturity contractors, Raytheon and Hughes, already on contract as the lead developers to satisfy all new Air Force requirements related to command centers, but they will use existing, certified software components from already developed systems to the greatest degree possible.[11] They have developed a fully functional command center to use as a "store" for operational users. The "store" utilizes multiple display and message passing technologies from existing programs along with pertinent pieces of commercial software and hardware. The operational users merely pick the desired pieces of functionality; they no longer have to help write a requirements specification, put up significant funding, and wait years for custom software to be written that often does not meet their needs.

The benefits are two-fold: First, it gets the government out of the business of developing custom software that already exists to perform most of the desired functionality. Second, the government already has two high software maturity firms on contract, so the user needs can be met much quicker without the government needing to go through the time consuming and often dysfunctional source selection process. The drawbacks, in terms of cultural change, are significant, however. Much of the procurement bureaucracy has not been receptive to this program. Reusing software and organizing around product lines requires fewer people and less funding, something many in the bureaucracy do not want to see.

Even though this is a pilot test, it appears to be very close to bearing fruit. The Air Force's current requirement to upgrade the military's U.S.-based air traffic centers appears to be doable using PRISM. The traditional custom software and system

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[10] Part of the reason for this predilection for timeliness measures is because they are easy to understand, easy to gather, and something managers in both government and industry have been trained to use.

[11] Some of he ideas behind PRISM trace back to the Software Engineering Institute's participation in Air Force's Granite Sentry program (a command center system). The SEI's Michael Rissman led a team of designers that discovered that much of the planned programming to accomplish various pieces of functionality went through the same five or six basic processing steps.

approach managed out of a government program office (SPO) has been priced in excess of $300 million. The PRISM approach using existing certified components currently in their repository and commercial hardware is priced at under $30 million. If this pilot proves successful,[12] it should provide significant impetus for the rest of the government to embrace product-line acquisition.

• **Do Not Initiate Incentives For Defect Metric Targets:** The government should endorse the use of quality metrics by industry, assuming the respective contractor has reached a level of process maturity where the metrics can be effectively used. The government, however, should not engage in placing specific product quality goals or targets on contract or in the form of an incentive. To place quality targets or metric measure levels on contract or in the form of an incentive causes the following problems:

- It places the government in the position of telling industry how to administer its program,
- It assumes something about the respective contractor or government program office that most often is not true—mature enough to use the metrics effectively, and
- It introduces a host of dysfunctional incentives [26] to the contractor organization to meet the incentive targets rather than the goal the incentive was seeking (high quality products).

Instead, the government should focus on awarding contracts to organizations possessing high software process maturity levels and ensure the process maturity is augmented or maintained over the life of the respective contract. Higher maturity organizations will measure and seek to improve quality as a normal business practice. We need to identify those firms and channel a greater percentage of our diminishing funding to them.

[12] Success in this case requires a broader meaning. Even if this pilot exceeds its budget by 100 percent, like most software acquisitions, it is still at least five times cheaper than a traditional SPO's current estimate.

The four components of the remedy are complementary; i.e., they should be implemented together for the government and industry to derive the maximum benefit from SPI.

Future Prospects and Conclusions: This paper represents the first step in understanding the economics of SPI. Still, more work needs to be done to better understand how SPI affects the economics of procurement. We have presented a theory of why differential SPI results are being witnessed in the government contractor sector. More work needs to be done before we can generalize these findings across all of industry, but we suspect they are relevant to organizations that develop significant pieces of customized software for internal use. Further work is also needed to understand the causality of how SPI relates to product lines: Is software process maturity more attractive to product line builders or does software process maturity cause an organization to focus development around a product line? Naturally, we suspect the latter. Our analysis also needs to continue in order to develop estimates by acquisition size for each of the variables discussed.

We find the data to be supportive of our theory that organizations that control the life cycle of their products possess greater incentives to engage in sound SPI programs. The government can reap greater benefits from SPI by motivating its contractors to continue their efforts through effective incentives. The incentive will have greater leverage within companies that have organized their development activities around a product line. This motivation is accomplished through economic incentives for SPI, not contractually-mandated SPI programs or target defect levels.

Similarly, there is a product-line lesson there for the government. It, too, should organize its procurements around product lines using the lessons learned from PRISM. This would allow the government to develop and deliver high quality products quicker and cheaper using high software maturity firms while overcoming the government's dysfunctional source selection process and its

associated inability to use past performance effectively.

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Implementation of Earned Value:
A Model Program Approach

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ABSTRACT

The following is an outline for how to implement the DoD Cost/Schedule Control Systems Criteria (C/SCSC) and related reports in a manner that maximizes management value for both the government Program Management Office (PMO) and the contractor. This paper is for discussion purposes only.

INTRODUCTION

While it is believed that little, if anything, in current policy precludes implementation of any of the following proposals, this paper proposes a radical change in how we do business and probably cannot be implemented piecemeal. It requires a complete government and contractor management commitment to making earned value and fully integrated management systems, essential elements of how we manage large, risky contracts.

1. Objective: Change the emphasis from the government to the contractor. C/SCSC compliant systems should represent how the contractor manages. The mere act of awarding a contract should not trigger a government review. Reviews should be conducted only for cause.

- Replace standard C/SCSC contract clause with a clause requiring executive level company certification that the contractor's management systems and procedures are fully integrated, reflect how the contractor manages, and meet the intent of the C/SCSC.

  - Subordinate the standard C/SCSC clause to the self certification clause, to be invoked only if DCMC and PMO surveillance, coupled with review of the Cost Performance Report (CPR), suggests faulty certification.

    -- This is a unilateral determination on the part of the government.

2. Objective: Reduce the review burden on both the government and contractor, and emphasize the presence of value in the management systems, rather than the absence of deficiencies.

- Initiate a Memorandum of Agreement with the DPRO ensuring regular surveillance of the "certified" management systems.

- Replace the buying activity's normal C/SCSC review(s) with (a) assistance visits to the DPRO to ensure establishment of an effective surveillance program, and (b) participation in DPRO surveillance reviews.
  - Deficiencies identified by joint DPRO/buying activity surveillance reviews to be evaluated against the CPR to determine if the deficiency

has a material impact on the quality, timeliness, or utility of the reported data.

-- If so, consider appropriate corrective action to include invoking a formal C/SCSC review.

-- If not, no action is required.

3. Objective: Put earned value in its proper context as an integrating tool for cost, schedule, and technical management.

- The C/SCSC are inherently a management requirement, not a reporting requirement. Consequently, the contract statement of work (SOW) should include the requirement for the contractor to manage using (among other things) earned value. The SOW should also reflect the requirement for the periodic (usually monthly) contractor/PMO reviews to include discussion of technical and schedule problems in their earned value context.

4. Objective: Limit reporting to what can and will be effectively used.

- Consider how the PMO is (or will be) organized to manage the effort and tailor reporting to those needs.

- Assign CPR analysis responsibility to the cognizant PMO technical organizations.

- Change the traditional "program control" or "business management" staff's CPR analysis responsibilities to those of an internal PMO staff oversight activity, charged with ensuring that the sum of the individual technical staff analyses represents a reasonable whole.

- Structure CPR formats 1& 2 to reflect the way the PMO and contractor view the effort.

-- For example, if the PMO is organized by integrated product teams (IPTs), wants to manage cost, schedule, and technical performance by IPTs, and has no need for the "standard" WBS format, don't buy it (Note: this does not obviate the need to establish a MIL-STD 881B compliant WBS. That need transcends this issue, and is beyond the scope of this discussion).

-- Similarly, if the contractor is not organized in a "traditional" functional manner, don't ask for a functionally formatted CPR format 2. The contractor should be free to structure format 2 to reflect how he is organized to manage. If the PMO has no interest in seeing the contract status as the contractor views it, format 2 should be eliminated. If the contractor manages and views status in the same manner the PMO does (e.g., IPTs), there is no need for format 2.

-- Consider eliminating CPR format 5's written variance analysis, or at least limiting it to the most significant variances as determined by

the contractor. This should allow submission of the CPR 5-10 days after the close of the "books". Minimal recurring, written variance analyses, can be augmented by a requirement for the contractor to provide variance analyses as requested based on PMO staff review. These can be written or provided at the monthly contractor/PMO reviews (see item 3 above).

5. Objective: Ensure comprehensive planning (one of the major benefits of C/SCSC), and common understanding of the task by both parties.

- Conduct a baseline planning review as early as possible after contract award.

  - Surveys have shown that baselines are established within six months of contract award, but C/SCSC demonstration or subsequent application reviews occur 12 to 18 months after contract award. Management of the contract cannot wait for the C/SCSC review.

  - The baseline planning review should be PMO led, consisting primarily of PMO technical staff with buying activity C/SCSC staff in a supporting role.

    -- Focus is on government and contractor technical manager counterparts reviewing cost account planning to ensure total coverage of the statement of work, proper scheduling, and adequate resourcing.

    -- All cost accounts should be planned, at least to a summary level, to the end of the contract. Any cost accounts that cannot be established in the initial planning effort should have the critical defining event(s) necessary for planning identified and made an item of continuing management interest.

GOVERNMENT ACQUISITION STRATEGY IN THE CRUISE MISSILE PROGRAM

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ABSTRACT

Three case studies involving the cruise missile Tomahawk air vehicle, sustainer engine, and inertial navigation element examined government acquisition strategy and how this affected program cost, performance, and schedule outcomes. The government acquisition strategy was focused on decreased production phase: cost and improved performance (reliability) for the air vehicle; decreased schedule length and risk for the sustainer engine; and decreased schedule length and risk and cost for the inertial navigation element; and was largely successful in meeting these goals. However, a key factor that impacted the government acquisition strategy in these subsystem procurements was the degree to which the government controlled data rights and had a viable technical data package.

INTRODUCTION

An important part of the process of understanding acquisition management methods is through the accumulation and analysis of experience from mature projects, especially if those projects involved unusual situations or innovative management techniques.

This paper documents the experience from 1977 to mid-1988 of one such activity: the Joint Cruise Missiles Project (JCMP). That project involves some unusual situations and innovative techniques that may also be applicable to future projects:

1.) A family of missiles with a high degree of commonality between models was developed concurrently; these models incorporated advanced technology and performance capabilities.

2.) Prime contractor competition was maintained until the end of the Air Launched Cruise Missile (ALCM) Full Scale Development (FSD), a rare occurrence in major military system acquisition.

3.) An unusually high degree of competitive dual sourcing was initiated by the government project office during FSD for introduction in the production phase. The government strategy was pursued as a possible means to meet the ALCM deployment schedule (F107 engine and Inertial Navigation Element (INE)), reduce cost (INE and Sea Launched Cruise Missile (SLCM) and Ground Launched Cruise Missile (GLCM) airframe) and increase performance (SLCM and GLCM airframe). The government strategy has also resulted in the project office dealing directly with an extensive set of associate contractors rather than a single prime contractor.

Any one of these features is rare among recent and current military system acquisition projects, and the combination of all three makes the cruise missile project unique.

Three cruise missile program case studies were performed: (1) the Tomahawk (GLCM and SLCM) air vehicle; (2) the F107 sustainer engine for the ALCM, GLCM, and SLCM; and (3) the INE for the ALCM, GLCM and land-attack SLCM. Each subsystem used in the three case studies is of critical importance to a large share of the first generation cruise missiles that have been deployed.

The events examined in this paper are mainly since January, 1977 when the Joint Cruise Missiles Project Office (JCMPO) was formed following the Defense Systems Acquisition Review Council (DSARC) II review. Each service had an active cruise missile development project for several years before 1977. The earlier period is briefly discussed to provide some historical continuity, but the focus of the paper is on the FSD and production phases. Similarly, a May 1988 cutoff date is used for the three cruise missile case studies (except in one instance).

While the cruise missile Tomahawk air vehicle, sustainer engine, and INE case studies are fairly thorough, they are not intended to form a complete and detailed project history.

BACKGROUND

The first generation modern cruise missiles are the: (1) Air Force ALCM, which includes the Boeing Aircraft Company (Boeing) airframe, Williams International Corporation (Williams) F107 sustainer engine, and the Litton Inertial Navigation Element (INE); (2) GLCM, which includes the General Dynamics/Convair Aerospace Division (General Dynamics) Tomahawk airframe, F107 engine, and McDonnell Douglas Corporation (McDonnell Douglas) guidance subsystem; and (3) SLCM (originally known as the Submarine Launched Cruise Missile), which includes the Tomahawk airframe, F107 engine, and McDonnell Douglas guidance subsystem. (The Tomahawk is a generic name representing the first generation GLCM and SLCM. F107 will be generically used to designate the ALCM sustainer engine (F107) and the GLCM and SLCM sustainer engine (F407). INE will be generically used to designate the inertial navigation platform, digital computer, and power supply for the land-attack Tomahawk (GLCM and SLCM) and Boeing (ALCM) cruise missiles. The resulting components are actually known as an Inertial Navigation Element (INE) for Air Force applications and Reference Measurement Unit and Computer (RMUC) for Navy land-attack applications.)

Numerous cruise missiles had previously been developed, and in some cases deployed, prior to the ALCM, GLCM, and SLCM. These weapon systems included the Snark, Matador, Hound Dog, and Harpoon. What sets the ALCM, GLCM, and SLCM apart from these earlier cruise missiles is: (1) their compact size, which permits increased numbers to be carried per platform, in part due to a miniaturized nuclear warhead (ALCM, GLCM, and nuclear-armed land-attack SLCM); (2) their low observables, which increases their chances of reaching the target, due to their low radar cross-section design, small size, and the Williams F107 turbofan engine (with its reduced infrared signature versus a turbojet engine); (3) design features such as their relatively long range, which permits additional targets to be attacked, due to the highly efficient F107

engine; and (4) their high accuracy, which increases the chances of target kill, due to the McDonnell Douglas guidance system which incorporates in-flight terrain contour matching updates to improve accuracy. In general, earlier cruise missiles were lacking in each of these areas. (For the remainder of this paper, the ALCM, GLCM, and SLCM are referred to as first generation cruise missiles.)

TOMAHAWK AIR VEHICLE CASE STUDY

As previously mentioned, Boeing and General Dynamics were the developers of the ALCM air vehicle and GLCM and SLCM airframe, respectively. President Jimmy Carter's cancellation of the B-1A bomber program on June 30, 1977 in favor of the long-range ALCM carried by the B-52 bomber elevated the ALCM development program to a high level of national importance. The government established a FSD competitive flyoff between the Boeing and General Dynamics cruise missiles to establish the best design. Had General Dynamics won the ALCM competition, the government would likely have made Boeing the production second source for the ALCM airframe, and possibly for the GLCM and SLCM airframes, thus forcing production phase competition between General Dynamics and Boeing. However, Boeing was declared the ALCM competition winner on March 25, 1980, and on April 30, 1980 it was made the sole ALCM airframe production supplier.

This left General Dynamics and McDonnell Douglas as the sole production sources for the Tomahawk airframe and guidance subsystems, respectively. The government was concerned about General Dynamics' cost inefficiency and what it believed to be an excessive short-term profit orientation. In addition, the government was concerned about inadequate missile airframe reliability, which directly affects performance, and could adversely impact production delivery schedules. For example, by August 1981 the General Dynamics' Tomahawk airframe had exhibited a pattern of flight test failures related to quality assurance problems followed by close government scrutiny that resulted in flight test successes. (These cyclical sequences demonstrated that the problems were correctable and partially due to insufficient manufacturing discipline by General Dynamics; these failures led, on June 22, 1982, to the most severe censure ever issued against a defense contractor for quality assurance problems [1].) The government was also concerned about McDonnell Douglas cost inefficiency and profit maximizing behavior in supplying the guidance subsystem.

The initial Tomahawk air vehicle cost, performance, and schedule solution point was unacceptable to the government, given the high air vehicle cost and that General Dynamics' airframe reliability problems left performance below the minimum required by the government.

The government's main desire was to decrease Tomahawk production cost while increasing performance (reliability). General Dynamics and McDonnell Douglas did not have a strong incentive to correct the problems while in a sole source mode. Both were powerful defense contractors and operating with undefinitized letter contracts since 1976, which gave them an advantage over the government in justifying high program costs and increased profits. As a result, the government considered the possibility of dual sourcing the Tomahawk airframe and guidance subsystem.

General Dynamics initially resisted government attempts to second source the Tomahawk airframe. It also wanted McDonnell Douglas as a subcontractor for the guidance subsystem, which would have increased General Dynamics' cost (thus potentially lowering its overhead rate) and profit, because profits were calculated in part as a markup over costs. However, by mid-1981, McDonnell Douglas had more incentive to accept a dual sourcing arrangement than General Dynamics because the Litton INE portion of the guidance system was separately contracted to the government on February 27, 1981 rather than subcontracted to McDonnell Douglas (it was about 65 percent of the total McDonnell Douglas guidance system contract value), thus considerably reducing McDonnell Douglas potential contract dollar amount and profit.

The government leveraged General Dynamics to participate in Tomahawk dual sourcing in late 1981 through two actions. First, it invited key McDonnell Douglas personnel to the General Dynamics' facility for familiarization. Second, it informed General Dynamics on November 12, 1981 of the advantages and disadvantages of not participating in a dual sourcing agreement. The negative consequences of General Dynamics nonparticipating outweighed the benefits. These two actions were the turning point in gaining General Dynamics' cooperation to develop a suitable second source plan, as General Dynamics' apparently realized that the government was serious in adopting the dual source acquisition strategy.

The government reviewed four possible acquisition strategies to obtain a more satisfactory outcome; they all involved a second production source and some form of competition. These options involved procurement by: (1) a second producer using the General Dynamics' airframe technical data package as the principle medium for transferring technology, (2) airframe alternate design, (3) identical design airframe-only dual sourcing using a Leader/Follower procurement strategy, and (4) identical design air vehicle (airframe and guidance system less F107 engine) dual sourcing using a Leader/Follower procurement strategy. None of these options would provide the government with a more competitive cost, performance, and schedule situation during cruise missile development, but rather, were oriented towards production improvements. These options were part of the government strategy to achieve higher airframe reliability and lower air vehicle production costs while still meeting production delivery schedules.

Although the government had paid for a Tomahawk airframe data package, it was not thorough enough to permit another contractor to fabricate the airframe, particularly given that cruise missile production techniques employed precision machining and welding rather than the more traditional fabrication method using rivets. The government faced the possibility with the technical data package option of a considerable development cost increase, coupled with only limited production cost reduction. However, some potential improvement in reliability would likely result.

An alternate design airframe suitable for sea, and particularly submarine, launch would have represented a major development activity due to launch and storage environment considerations. This approach would have resulted in increased development cost and schedule, with only limited production cost reduction likely. However, some potential improvement in reliability would probably result with this second source option.

The airframe identical design Leader/Follower approach would have involved selecting a second contractor to fabricate the Tomahawk airframe. A Leader/Follower arrangement differs from a technical data package approach in that the Leader actually participates in the technology transfer process, which involves considerable effort on the part of the Leader. With this option the government would have faced increased development cost for technology transfer between General Dynamics and the second contractor, with only moderate production cost reduction likely. However, some potential improvement in reliability would probably result.

The air vehicle identical design Leader/Follower option, which was actually implemented, involved selecting a second contractor to fabricate both the Tomahawk airframe and guidance subsystems. (In this case the F107 engine was provided by the government to each contractor.) General Dynamics and McDonnell Douglas were chosen to be the Followers on each other's guidance and airframe subsystems, respectively. The government proposed to General Dynamics and McDonnell Douglas a series of measures to efficiently carry out the technology transfer process and reduce the level of government up-front funding necessary to implement dual Tomahawk production sources. It also provided the companies an acceptable assurance that in the event of an early Tomahawk program cancellation, costs incurred by the contractors technology transfer, tooling, and test equipment would be covered by cancellation payments.

The air vehicle identical design Leader/Follower dual source option had the potential to yield considerable production cost savings due to the intense rivalry between General Dynamics and McDonnell Douglas in general as well as specifically for cruise missile business. Production reliability improvements were also likely because of the competitive nature of the government acquisition strategy. Not only did a yearly price competition exist, but other factors, including quality assurance and the ability to meet delivery schedules, were part of the source selection criteria. The air vehicle identical design Leader/Follower dual source option also had the potential to provide the shortest Follower initial delivery time due to the non-hostile nature of the technology transfer process. In fact, only the air vehicle identical design Leader/Follower dual source option eliminated the somewhat complicated contractual problem of selecting and establishing the second source, since General Dynamics and McDonnell Douglas became the Follower on each other's Tomahawk subsystem.

The air vehicle identical design Leader/Follower option was selected by the JCMPO, and approved by the Department of the Navy on January 18, 1982. The government justification used to gain approval to implement this dual source approach was that it would increase the industrial mobilization base compared to the other dual sourcing options. While the justification was needed to gain higher level government approval, the program office's main goal was to decrease production cost, improve performance, and meet the delivery schedule.

The government acquisition approach, coupled with a large SLCM procurement quantity increase in December 1981 (3994 versus 644 in March 1981), made dual sourcing the Tomahawk air vehicle a viable option for all parties. The government's dual sourcing plan was accepted by General Dynamics and McDonnell Douglas in FY82 and the first year of head-to-head

competition between contractors was in FY85.

From FY85 through FY88 General Dynamics won three of the four annual split-buys (FY85, FY86, and FY88) against McDonnell Douglas and an average quantity of 58 versus 42 percent. McDonnell Douglas won annual split-buys in FY89, FY91, and FY92 (while General Dynamics won in FY90 and the FY91 supplemental buy). The ability of McDonnell Douglas (Follower) to win four of the nine annual split-buys through FY92, coupled with a strong competition in FY87 through FY92, indicates that the Tomahawk air vehicle production phase dual sourcing competition has indeed been viable.

The outcomes through FY88 of the air vehicle identical design Leader/Follower acquisition approach include: (1) production cost savings, estimated to be several hundred million dollars or more, over that projected for both companies operating in a sole source role; (2) a reduction in quality assurance problems; and (3) the ability to meet production delivery schedules. For example, the JCMPO estimated a $0.46 million (FY87) decrease in air vehicle average unit cost for the FY88 buy versus sole source projections [2]. Given the FY88 buy of 475 air vehicles, a substantial savings likely occurred in this year alone.

The shift in the outcomes from the original sole source production plan is largely tied to the government acquisition strategy which provided an incentive to both contractors to reduce inefficiency through the use of competitive annual missile buys. It is also the result of an existing rivalry between General Dynamics and McDonnell Douglas that has led to a strong price competition on the Tomahawk production program.

SUSTAINER ENGINE CASE STUDY

Williams International Corporation (WIC) was selected by the government as the Air Launched Cruise Missile (ALCM) and Sea Launched Cruise Missile (SLCM) sustainer engine contractor in mid-1973 and May 1976, respectively. This relationship was extended to the Ground Launched Cruise Missile (GLCM) program that was initiated in January 1977.

Although there was no reason to doubt the design or reliability of the F107 sustainer engine, WIC was, in early 1977, a small privately owned corporation with no high rate production experience and whose maximum business was less than $40 million per year. Engine fabrication times during the FSD program phase were far too long to support planned production delivery schedules. For example, it initially took 3 months to make one F107 engine combustor versus the potential need of fabricating up to 5 to 10 per day during production [3]. The government was quite risk averse to any possible ALCM production schedule slippage because of the increased importance of the ALCM once the B-1A was canceled by President Carter. The government was interested in reducing the potential production delivery schedule length.

The government also regarded the potential WIC F107 engine production cost as high, and indicative of inefficient contractor operation. However, reducing cost was of less concern during 1977-1978 than achieving an acceptable production fabrication capability.

The initial F107 engine cost, performance, and schedule solution point was unacceptable to the government, since the initial WIC F107 fabrication rate was far below the minimum required by the

government. In effect, the initial F107 delivery schedule was greater than the maximum allowable to meet the ALCM delivery schedule. Consequently, the government's main desire was to decrease production schedule length and risk, maintain demonstrated performance levels, and reduce production cost, if possible.

The government reviewed four possible options to obtain a more satisfactory outcome; they all involved some form of competition. These options involved procurement by: (1) engine technical data package, (2) engine alternate design, (3) identical design engine dual sourcing using a Leader/Follower procurement strategy, and (4) development of second sources for all critical or major engine subassemblies or parts except for the key fuel control unit (the single most expensive F107 engine component). Only option 4 would provide the government with a more desirable cost, performance, and schedule solution point during engine development, but it was insufficient as a stand alone option to greatly reduce the production schedule length. Conversely, the other options were mainly oriented towards potential production schedule improvements.

The acquisition strategy considered by the government was clouded by the WIC claim during 1977 that it held proprietary data rights on 145 F107 engine components. Although the burden of proof for rights to data would have been on WIC, the lengthy litigation process could have delayed the critical ALCM delivery schedule.

Because of the WIC claims, purchase of an F107 engine technical data package would have been expensive for the government, and would not have reduced the government's concern over production schedule length. The schedule concern was due to the complex fabrication process and tolerances employed in the F107 engine, and the possibility that not all necessary production knowledge would be included or successfully transferred in the technical data package. With the technical data package option the government faced the possibility of considerable up-front cost. In addition, if the second source was unable to assimilate the technical data package, then increased production cost and schedule length and decreased performance were possible.

An alternate design sustainer engine would have represented a major development activity due to the technical complexity of engine, thus increasing development cost and schedule. In addition, it may not have been capable of achieving the desired production delivery schedule, at least in the near-term, given that the time to qualify such an engine would have been several years. This long a qualification time would also have given WIC a considerable price competition advantage over the alternate design engine, and thus, only limited production cost reduction, if any, might result (versus WIC sole source production). Finally, potential performance improvements from the alternate design engine were estimated to range from zero to only a few percent. Given that the government viewed F107 engine performance as satisfactory, an alternate design engine with, at best, only a marginal increase in performance did not present a convincing argument for selection on technical grounds.

The identical design Leader/Follower approach would have involved selecting a second contractor to fabricate the F107 engine. Because of WIC's claim to data rights, the government would have incurred considerable up-front cost for technology transfer between WIC and the second contractor, with only limited to moderate

production cost reduction. The identical design Leader/Follower option would have likely provided the desired decrease in production F107 engine delivery schedule, while maintaining engine performance achieved by 1977. The alternate subassembly and parts suppliers option was not viewed as a sufficient stand alone approach to achieve the desired production engine delivery schedule, but rather as a means of augmenting one of the other options to reduce F107 engine production risk.

The alternate subassembly and parts suppliers option was chosen on November 2, 1977, while a modified form of the sustainer engine identical design Leader/Follower option, was selected by the government in March 1978. The modified Leader/Follower option kept the Follower as a subcontractor to WIC for the duration of the engine buy. (Separately contracting with the Follower was possible, but would have required royalty payments be made to WIC.)

WIC initially attempted to pick a Follower with limited applicable production experience to prevent a successful production price competition. The government did not approve the WIC recommended contractor and suggested that a contractor be named with considerable high rate production experience to minimize potential schedule risk. WIC then reconsidered its Follower selection and proposed Teledyne Corporation, Continental Aircraft Engine Division (TCAE) on September 18, 1978. TCAE was acceptable to the government since they were competitively developing the F106 engine against WIC in the early phase of the SLCM program and had high rate, small engine production experience with the Harpoon F402 turbojet engine.

Given that TCAE was to remain a subcontractor to WIC, the up-front cost to the government was considerably less than if it had a direct contracting relationship with the government. However, the reduced up-front cost must be balanced against the potentially higher production cost with this approach since WIC was guaranteed a monthly minimum buy and TCAE was limited to a monthly maximum buy. The modified Leader/Follower option also had the best chance of meeting the necessary production delivery schedule, while maintaining the acceptable F107 engine performance that had already been achieved.

The outcomes through FY88 of the identical design Leader/Follower procurement approach include: (1) meeting the production delivery schedules for the ALCM, GLCM, and SLCM; (2) reducing F107 engine cost as compared to cost in the FSD phase; (3) and maintaining acceptable F107 engine performance.

The shift in the cost, performance, and schedule solution point is largely tied to the government acquisition strategy which established a second F107 engine production source. Although the technology transfer process between WIC and TCAE was not initially without problems, it forced WIC to closely examine and "rethink" the engine fabrication process. As a result, WIC become a more efficient and lower cost turbofan engine manufacturer. This benefited the government by providing the desired reduction in engine fabrication time, as well as some decrease in cost.

It is difficult to say that the government Leader/Follower dual source acquisition strategy could be justified on a cost basis, since the retention of TCAE as a subcontractor to WIC, coupled with the monthly WIC minimum and TCAE

maximum buys, guaranteed WIC getting the majority of each years split-buy and effectively eliminated an open price competition. The key to the limitation was the data rights issue. By 1980 it had been estimated by the government that the validity of WIC's data rights claims on the 145 F107 engine components had greatly eroded, due to patents expiring and invalid claims against other components. Unfortunately for the government, the weak WIC position was not known until almost 1 1/2 to 2 years after signing the dual sourcing arrangement with WIC in 1978. Consequently, potential cost savings that may have occurred through an open production dual source competition was not possible in the F107 engine case.

INERTIAL NAVIGATION ELEMENT CASE STUDY

Litton Guidance and Control Systems Division (Litton) was selected by Boeing Aerospace Company as the Air Launched Cruise Missile (ALCM) inertial navigation element (INE) contractor in mid-1973. In October 1975 McDonnell Douglas Astronautics Company was selected as the Sea Launched Cruise Missile (SLCM) guidance system contractor, with Litton as its INE subcontractor. The McDonnell Douglas/Litton relationship was extended to the Ground Launched Cruise Missile (GLCM) program that was initiated in January 1977.

There was little reason to doubt the design, performance, or reliability of the Litton INE since it had already been extensively flight tested, and a closely related INE was developed and satisfactorily tested, in the F-15 aircraft by January 1977. However, as in the F107 engine case, the government was interested in reducing the production schedule length and risk in order to meet the ALCM delivery schedule.

The government also regarded the Litton INE production cost estimates as moderate to high, and indicative of inefficient contractor operation. Given the government experience in reaching the F107 engine dual source agreement, in March 1978, it also considered the possibility that an INE production competition could result in cost savings.

The initial INE cost, performance, and schedule solution point was unacceptable to the government, since the initial INE fabrication rate was likely below the minimum required by the government. In effect, the initial INE delivery schedule was probably greater than the maximum allowable to meet the ALCM delivery schedule. In addition, the initial INE cost was likely near the maximum government level. Consequently, the government's main desire was to decrease production schedule length, maintain demonstrated performance levels, and reduce production cost.

The government reviewed four possible options to obtain a more satisfactory outcome; they all involved a second production source and some form of competition. These options involved procurement by: (1) INE technical data package, (2) INE directed licensing, (3) INE alternate design, and (4) identical design engine dual sourcing using a Leader/Follower procurement strategy.

The acquisition strategy considered by the government, as in the F107 engine case, was clouded by the Litton claim to data rights on 15 or more key INE components [4]. In the INE case, McDonnell Douglas and the government realized that the Litton claim to data rights was likely valid.

Because of the Litton claim, purchase of a INE technical data package would have been expensive for the government, and would not have reduced the government's production delivery schedule concern. The concern was due to the complex fabrication process and tolerances present in the key INE components (e.g., gyroscope and accelerometer), and the possibility that not all necessary production knowledge would be included or successfully transferred in the technical data package. The government would have had to pay a considerable up-front cost to Litton for the technical data package. In addition, if the second source was unable to assimilate the technical data package, then increased production cost and schedule length and decreased performance were possible.

Litton was unwilling to license another contractor to fabricate key INE components (e.g., gyroscope and accelerometer) unless a substantial fee was paid. However, this acquisition approach would also not have reduced the government's production delivery schedule concern for the same reasons as given for the technical data package. As in the technical data package case, the government would have had to pay a considerable up-front cost to Litton to proceed with the licensing option.

An alternate design INE represented a moderately complex development activity due to component development as well as subsystem integration that would be necessary, thus increasing development cost and schedule. In addition, it may not have been capable of achieving the desired delivery schedule in the early portions of the ALCM production phase. The added time to qualify the Follower would also have given Litton a considerable price competition advantage over the alternate design INE, and thus, only limited production cost reduction might result (versus Litton sole source production). Finally, potential performance improvements from the alternate design engine were estimated to be non-existent. Given that the government viewed the Litton INE performance as satisfactory, an alternate design INE with, at best, the same performance did not present an argument for selection on technical grounds.

The identical design Leader/Follower approach would have involved selecting a second contractor to fabricate the INE. Because of Litton's claim to data rights, McDonnell Douglas and the government were prohibited by Litton to implement this approach in an unmodified form. The identical design Leader/Follower option would have likely provided the desired decrease in the production INE delivery schedule, while maintaining INE performance achieved through 1978.

Litton stated in May 1978 that the key to a successful technology transfer was the ability to transfer processes and know-how, not products, and that they had done it successfully 36 times in the past with other Litton divisions [5]. Litton proposed Litton Systems Limited (LSL) as the potential INE Follower in June 1978, and stated that there had been effective head to head competition between these two divisions seven times in the past. Both McDonnell Douglas and the government recognized that the Litton proposed dual sourcing approach provided the lowest risk and up-front cost to the government, the ability to meet production delivery schedules, and the potential for production cost savings.

The Litton proposed dual sourcing approach was selected by McDonnell Douglas and the government on October 13, 1978. It involved maintaining Litton as the Leader, selecting LSL as an independent contractor

as well as the Follower to fabricate the INE, and keeping both Litton divisions as a subcontractor to McDonnell Douglas (for the GLCM and SLCM). Other provisions of the technology transfer agreement between Litton and LSL included the waiving of royalty charges and license fees, a capital investment incentive clause to purchase necessary equipment to achieve rate production, a profit level cap depending upon contract type, minimum production quantity awards for each Litton division based upon the annual production buy, and the ability for the government to purchase all INEs from a single Litton division if the other division's performance or price was not acceptable.

The terms of the agreement were more favorable to the government on a point by point basis than those reached with WIC for the F107 engine dual sourcing arrangement. For example, while a monthly minimum buy was established for each Litton division, no monthly maximum was included, and thus a greater chance existed for an open price competition between the two suppliers than in the WIC and TCAE sustainer engine case discussed (all other things held constant).

Given the use of LSL as the Follower, coupled with a capital investment incentive clause, the up-front cost to the government was minimal and considerably less than if any other option had been chosen. The identical design Leader/Follower approach also potentially had the lowest schedule risk, including meeting the necessary production delivery schedule, while maintaining the acceptable INE performance that had already been achieved.

On February 27, 1981, the government broke-out the INE from McDonnell Douglas and contracted directly with Litton and LSL in an attempt to further reduce potential production costs. The first year of head to head competition between the two Litton divisions was FY81. From FY81 through FY88, Litton and LSL won 2 and 6 of the 8 total competitive split-buys, respectively. (The average quantity won by Litton and LSL through FY88 was 42 and 58 percent, respectively.) The Follower, LSL, won the majority of the annual split-buys from Litton, the INE developer, from FY81 through FY88. LSL won the first four annual split-buys, but during FY85 through FY88, neither Litton division won two consecutive annual competitions. The competent Follower showing in winning the majority of the split-buys, coupled with a strong competition in FY85 through FY88 is indicative of a vigorous production dual source competition.

The outcomes through FY88 of the identical design Leader/Follower procurement approach include: (1) meeting the production delivery schedules for the ALCM, GLCM, and SLCM; (2) a reduction in INE cost in the production versus the development phase; (3) likely production cost savings versus keeping Litton in a sole source role; and (4) maintaining acceptable INE performance.

The shift in the cost, performance, and schedule solution point is largely tied to the government acquisition strategy which established LSL as the second INE production source. It is also related to the much more favorable technology transfer terms the government had between Litton and LSL versus WIC and TCAE in the F107 engine case, coupled with a strong production phase dual source competition between the Litton divisions (as discussed above).

CONCLUSIONS

The three cruise missile cases evaluated here represent a broad range of programmatic conditions for the government and contractors. In each case, the government used production phase dual sourcing as a means of reducing one or more undesirable cost, performance, or schedule characteristics present in the development phase. However, the production phase outcomes for the three subsystems were largely dependent upon the FSD "starting point" between the government and contractors.

The primary government objectives were different for each production phase competition. For the sustainer engine, the government attempted to reduce fabrication schedule length and risk; for the INE, reduce fabrication schedule length and risk, and reduce cost; and for the AUR, reduce cost and improve performance (reliability). The government achieved its objective in each case. However, the government objectives and the resulting level of success will likely vary on a case by case basis, even within a given program.

The ALCM, GLCM, and SLCM programs were all programs of the highest national importance and held a BRICK-BAT DX priority rating early in the FSD phase. The ALCM program had the earliest deployment date of the three, and this coupled with the large initial production quantity (3418) necessitated the timely fabrication and delivery of the sustainer engine and INE.

In the three cruise missile cases, the first open competition year was two to three years after agreement was reached to hold the competition. Had other dual sourcing strategies been used (e.g., an alternate design), the length of time to the first competition year would have likely increased, thus diminishing the government's ability to achieve its primary objective in the sustainer engine and INE cases (meeting the ALCM delivery schedule and decreasing INE cost), as well as in the AUR case (reduce GLCM and SLCM air vehicle production cost, improve reliability, and meet the delivery schedules).

An identical design, leader/follower form of dual sourcing was used in each case, but this may not be optimal or even desirable for other programs. In a broader sense, the decision as to whether or not production phase competition is warranted varies with a host of economic, programmatic, and technical considerations. A partial list of relevant considerations includes the rationale for competition (e.g., purely economic), availability of an acceptable second source, the degree of potential rivalry between the contractors, economic considerations (e.g., annual production rate and total quantity), production quantity constraints per contractor (e.g., a guaranteed minimum), government source selection criteria, and the type of competition. Few simple universal guidelines apply as to whether or not a production phase competition will be successful.

For example, the government must separately view and analyze the potential competition structure versus the likely contractor behavior. These considerations both shaped the government acquisition strategy and impacted the degree of success achieved in the cruise missile engine and INE competitions.

Both WIC (engine) and Litton (INE) claimed rights to data. The government could not delay ALCM deployment to argue the legal merits of these contractor claims. In all likelihood, the WIC claims were weak or negligible by the time ALCM production began, while those made by Litton were

viable. However, even in the engine case the government had little real choice but to accept the WIC claim because of the tight ALCM deployment schedule. In effect, there were no close substitutes for the WIC F107 engine. Any other engine would have required moderate development, and was undesirable from a cost, performance, and schedule point of view. Similarly, in the INE case the best available substitute was not acceptable from a cost and schedule perspective.

Although both WIC and TCAE had already been competitors in the cruise missile engine business, the substantial constraints imposed on the competition structure resulting from the WIC claim to data rights precluded TCAE from ever winning the majority of a yearly split-buy competition. On the other hand, Litton and LSL were sister divisions of the same company, and this might by itself suggest a weak price competition. However, Litton and LSL had a history of strong rivalry when competing on prior programs. This coupled with less restrictive requirements for a Litton monthly minimum award quantity and a LSL maximum monthly award quantity led to a substantially stronger price competition than in the sustainer engine case.

The AUR production competition success was largely due to four reasons. First, each contractor strongly desired obtaining business in the other's arena. Second, the two experienced cruise missile contractors cross-licensed their respective subsystems and transferred the technology to each other at minimal charge. Third, a strong rivalry existed between the two companies. Fourth, much of the credit for the success belongs to JCMPO personnel, who envisioned the possible competition structure and worked through many substantial issues with both contractors, who were not initially receptive to the idea of production phase dual sourcing.

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SOME COMMON MINUTEMAN I, POLARIS A-1, AND ALCM DEVELOPMENT PROGRAM CHARACTERISTICS

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ABSTRACT

The "President's Blue Ribbon Commission on Defense Management," in 1986, identified three military programs, the Minuteman I, Polaris, and the Air Launched Cruise Missile (ALCM), as being examples of defense programs with streamlined procedures that achieved accelerated (development) schedules typically associated with successful commercial programs.

The Minuteman I, Polaris, and ALCM acquisition histories were examined to identify common characteristics present and to determine if lessons learned can readily be transferred to other DoD programs to potentially improve the odds of program success.

INTRODUCTION

The "President's Blue Ribbon Commission on Defense Management," in 1986, stated that: "It is clear that major savings are possible in the development of weapon systems if the Department of Defense (DoD) broadly emulates the acquisition procedures used in outstanding commercial programs" [1].

The Commission also stated that: "It is clear from our earlier description that defense acquisition typically differs from this commercial model in almost every respect" [2]. However, the Commission did name three military programs, the Minuteman I, Polaris, and (post-Milestone II) long-range Air Launched Cruise Missile (ALCM), as being examples of defense programs with streamlined procedures that achieved accelerated (development) schedules typically associated with successful commercial programs [3].

Only the post-Milestone II portion of the ALCM program used streamlined acquisition procedures. The long-range ALCM program (AGM-86B) was effectively initiated as a result of the cruise missile Milestone II decision memorandum on January 14, 1977. Prior to this time the long-range ALCM had only been a paper study. Now it was to be developed and given priority over the existing short-range ALCM (AGM-86A) the Air Force had been developing [4]. (Shortly thereafter, the short-range ALCM program ended.) The ALCM program was transferred to the Joint Cruise Missiles Project Office (JCMPO) as a result of the Milestone II decision memorandum. (The JCMPO was also created as a result of the Milestone II decision memorandum.) However, it was not until President Carter canceled the B-1A

program on June 30, 1977 and the September 30, 1977 memorandum from Undersecretary of Defense for Research and Engineering (USDR&E) Dr. William Perry to the Secretaries of the Air Force and Navy, that the JCMPO was given sufficient external support in order to implement a streamlined acquisition program for the long-range ALCM. (The ALCM flyoff was initiated in the same Dr. Perry memorandum eight months after the program entered Full Scale Development (FSD, now Engineering and Manufacturing Development (EMD).)

The development program acquisition histories of the Minuteman I, Polaris A-1, and ALCM systems were examined to identify: (1) some common characteristics of these programs and (2) whether or not the lessons learned can be transferred to other DoD programs to potentially improve the odds of program success.

COMPARISON OF MINUTEMAN I, POLARIS A-1, AND ALCM DEVELOPMENT PROGRAMS

The Minuteman I [5], Polaris A-1 [6], and ALCM [7] program schedules are summarized in Figures 1, 2, and 3, respectively.

Priority Rating

Each program was a program of the highest national importance, and held a BRICK-BAT DX priority rating. This rating provided assurance for availability of materials, components, and other resources (e.g., test ranges) in the event of conflict with commercial or lesser important defense contracts. The Minuteman I, Polaris (Fleet Ballistic Missile Program), and ALCM were assigned this rating in September 1959, November 1955, and February 1978.

Program Management Autonomy

Each program had considerable management autonomy. However, this did not prevent either bureaucratic encroachment or considerable programmatic turbulence from occurring during missile development (Minuteman I) or following development completion (Polaris A-1 and ALCM).

Conflicts between programmatic success and bureaucratic success exist and generally increase as a program nears completion. A potential cause of this problem is that tendencies towards suboptimization inherent in project management are exacerbated when the urgency of the mission declines [8].

In the Minuteman I case, Lt. Gen. Bernard Schriever was the commander of the Air Force Ballistic Missile Division and the deputy commander of the Air Research and Development Center (ARDC, which later became Air Force Systems Command). In essence, Lt. Gen. Schriever was his own supervisor, which gave him very strong control over funding and review authority through 1958 (early FSD program phase). However, upon becoming ARDC commander in March 1959, Lt. Gen. Schriever abolished special management by exception for the Minuteman I program office and the program no longer possessed such uncommon reporting and protective mechanisms [9].

Minuteman I management independence had declined considerably just prior to the March 1960 production decision, as evidenced in an excerpt of a letter from Lt. Gen. Schriever to Gen. Thomas White (Chief of Staff, USAF): ..."To insure a timely and effective force, our weapon system managers must possess the authority to effect necessary program changes. The

continual encroachment upon this authority is of great concern to me, and I urge that you consider a return to the streamlined management principles which were so effective in the Thor and Atlas programs." [10]

By February 1961, the Minuteman I management situation had become so difficult that Lt. Gen. Schriever expressed great concern to Gen. White. Lt. Gen. Schriever felt that although the Minuteman program was a high risk program requiring unusual measures in all respects to protect the operational dates, the program was being managed in a routine fashion [11].

Similarly, MGen. Osmund J. Ritland, Commander of the Air Force Ballistic Missile Division, in a February 17, 1961 letter to Lt. Gen. Schriever, drew attention to how the Navy had been supporting the Polaris program. MGen. Ritland indicated that the Navy had rallied to support Polaris development, and that there had been no change in program management since the beginning of the program. The program director had been given total authority and resources to carry out his assignment. For this: "...he had been asked for only one thing--results". [12].

The most important Minuteman I management strengthening measures occurred on February 23, 1961. Gen. White informed all deputies, directors, and chiefs of comparable offices that the Minuteman undertaking was a "...crash program." Therefore, all matters pertaining Minuteman high level program review were given "overriding priority", and reviews of the program were to be limited to a single review in the Air Staff with ARDC participation [13].

In the Polaris case, the Special Projects Office quickly learned that a reputation for managerial efficiency made it difficult for anyone to challenge the Polaris development plans. PERT (Program Evaluation and Review Technique, a computerized planning, scheduling, and control technique first made public in mid-1958), the Polaris Management Center, and other management innovations produced a protective veneer to allow Polaris development [14]. The degree of program protection provided by these innovations was of equal or greater value than the intrinsic management efficiency benefits of the techniques. They allowed the technical staff to work relatively unhindered and protected them from concerned but potentially disruptive outside officials.

Decentralization and competition were key components of the Polaris management strategy, which provided nearly self-regulating control over the Polaris development and its developers. Through decentralization, authority to act was given to those closest to the problems, yet competition among the program office branches and contractors assured the central staff that decisions affecting the vital needs of the entire system would be brought to their attention [15]. However, Department of the Navy restructurings in 1963 and 1966 eliminated much of the Special Project Office independence and management by exception [16]. Although this did not greatly affect the Polaris series of missiles (A-1, A-2, and the initial A-3), it did impact all subsequent Navy ballistic missile programs.

An Executive Committee (EXCOM) was established by the USDR&E Dr. William Perry, in September 1977 (early in FSD) to provide programmatic and fiscal direction to monitor the progress of the ALCM flyoff and other cruise missile variants. The

EXCOM was not a voting group; rather its purpose was to review and discuss in an attempt to establish a consensus. In the absence of a consensus, Dr. Perry would act as required and report dissenting opinions to the Secretary of Defense along with recommendations for action. Normal channels remained open to the Services to express dissent. Another EXCOM feature was that it provided a forum for an expeditious review of problem areas. In addition, through its high-level OSD and Service membership, and the use of action item assignments, EXCOM interaction with the JCMPO could potentially minimize program cost and schedule risk [17].

The EXCOM was a key element in the JCMPO management approach. In practice, the EXCOM served several functions. One function was to provide a periodic and structured forum for examining problem areas. Another function was that the EXCOM members had enough authority to resolve problems quickly, including resolution of funding shortages [18].

The ALCM began transitioning back to the Air Force from the JCMPO following its Milestone III review in March 1980. The cruise missile project EXCOM was discontinued after its final meeting on January 8, 1981. After that, the JCMPO director had no effective formal mechanism for resolving issues between the Air Force and Navy.

Although the cessation of the EXCOM did not affect ALCM development, it did potentially impact development of the Air Force Ground Launched Cruise Missile and the Medium Range Air-to-Surface Missile programs. Another effect was a psychological one in the minds of some JCMPO members and associated service officials. After the EXCOM was discontinued, some personnel took this action to mean in part that the level of Office of the Secretary of Defense (OSD) support for the cruise missile project had diminished. Although it was impossible to quantify, this factor undoubtedly had some non beneficial impact on the cruise missile project [19].

Early Program Support

None of the three programs had substantial support early in its history, but did receive substantial support by the middle development stages.

For example, the Minuteman I and Polaris programs were initiated after the four "approved" ballistic missile programs (Atlas Intercontinental Ballistic Missile (ICBM), Titan ICBM (backup), Thor Intermediate Range Ballistic Missile (IRBM), and Jupiter IRBM) were identified in September 1955 by President Eisenhower and the DoD [20]. In addition, early attempts to accelerate the Minuteman program schedule were not well received. Just prior to the Minuteman I FSD start, and 11 months after the first Soviet Sputnik was launched, W. M. Holaday, Department of Defense Director of Guided Missiles, wrote to James H. Douglas, Secretary of the Air Force, on September 17, 1958, noting that the Minuteman program: "is not in consonance with my desire for an orderly step-wise development program. The plan submitted is characterized by the compressed development schedules associated with the so-called crash programs such as Atlas and Titan which, while justified by the urgency of the requirement for an early ICBM capability, are not conducive to maximizing operational effectiveness or minimizing costs." [21]

Minuteman I had a less hectic development program than the Polaris A-1, partly because

it was in the awkward position of being competitive with more advanced liquid-fuel ballistic missiles being developed by the Air Force. Essentially all the critical uncertainties of Minuteman technology were reasonably well in hand by 1957, but activating a full-scale development program would inevitably cause a diversion of effort from the other ballistic missile programs to which the Air Force had commitments. Before Sputnik cut the purse strings, Minuteman I could have been developed only at the price of limiting expenditures of the Atlas or Titan programs [22]. The effect of the Sputnik furor in late 1957 and of the political squabbling that sputtered through the next three years was, in part, the accelerated development of the Minuteman I program (which was initiated on May 20, 1959).

Similarly, by March 1957 the Navy's Special Projects Office had settled on the general specifications of the Polaris missile, submarine, undersurface launch system, and related components. Acceleration of the original program on December 9, 1957 and substantial funding authorizations followed Sputnik. Cutting rather more than two years from the earlier schedules was achieved by compressing schedules, eliminating test sequences, and by relaxing both the range and accuracy specifications [23].

The long-range ALCM faced initial opposition from parts of the Air Force in favor of its much higher priority B-1A coupled with the short-range ALCM prior to President Carter's cancellation of the B-1A on June 30, 1977 [24].

In addition, none of the programs had considerable opposition from the scientific community beyond the early development stage.

Program Funding and Funding Turbulence

While each program received the necessary funding, potential funding shortfalls occurred which produced program turbulence in the short run.

In the Minuteman I case, an accelerated development plan was approved on May 20, 1959 (mid-way through FSD). By November 1959, the Minuteman I contractors were reporting the potential for large cost increases. The cost increases were the result of externally directed changes to the Minuteman program, including the accelerated schedule. Initially, the corresponding increases in the program budget did not match these externally directed changes, and substantial increases in Minuteman I funding were necessary during the early portion of the missile production phase in FY60-FY62 [25].

In the Polaris case: "An unexpected technical crisis would force internal reprogramming of funds to be undertaken. But inevitably money for all important activities was found, even if the lost time could not always be recovered. Program officials learned quickly to request generous contingency appropriations." [26]

On December 9, 1957 (at the start of FSD), the Secretary of Defense authorized acceleration of the Polaris program to deploy the first Polaris weapon system in 1960 [27]. Shortly thereafter, on February 12, 1958, President Eisenhower signed the FY58 Supplemental Appropriation Act, including funds for construction of the first three Polaris submarines. Construction had begun in January 1958 using funds "borrowed" from other Navy programs [28].

In the ALCM case, the FSD program flyoff completion date slipped approximately three months during the course of the competition (from November 1979 to February 1980) because of the late receipt of the FY78 supplemental appropriation [29], which was dedicated to the ALCM program.

While it is difficult to accurately estimate the impact of program acceleration on the development cost, the resulting increases were not minor for Minuteman I and ALCM. In the Minuteman I case, it is estimated that program acceleration added roughly 45 percent to the development phase cost, and was used for overtime for contractor employees and dual sources for critical items and tests [30]. In the ALCM case, a 41 percent cost growth occurred in the development phase-the largest contributors to this growth were the accelerated FSD schedule and some additional requirements imposed during the flyoff [31].

Necessary Technology Advancement

Each program represented a moderate technology advance required across the entire system, with a considerable advance in the state of the art required for only a few subsystems. In addition, each program was the beneficiary of important advances made from prior technology, development, or operational programs.

For example, in the Minuteman I and Polaris A-1 programs, important advances had already been made in the Atlas, Thor, and Titan ballistic missile programs, including reentry physics, development of electronic controls, and inertial guidance. In addition, key solid propulsion research had been started in the mid 1950s that provided an excellent bridge to Minuteman I and Polaris A-1 requirements. The "breakthrough" for each came in 1955 (prior to the commencement of either program) with demonstrations that large-grain, double-base solid propellants could be reliably ignited and burned [32].

In the ALCM case, key turbofan engine development had begun almost five years prior to the Milestone II decision to initiate development of the long-range ALCM in January 1977 [33]. Likewise, the guidance system Inertial Navigation Element (INE) was closely related to a unit that had already been developed and tested for the F-15 and other military aircraft. In effect, the technical characteristics of both the ALCM engine and INE were well in hand prior to the cruise missile Milestone II decision on January 14, 1977.

Common areas of technology advancement used by all three programs included improved propulsion and warheads.

Some common key technology areas for the Minuteman I and Polaris A-1 that required moderate development included: (1) high energy, solid propellants with advanced binders and additives, and uniform character, which provided improved thrust and reliability; (2) improved materials (e.g., with increased strength and reduced weight), which contributed to increased range; (3) thrust vector control and thrust termination devices, which improved missile accuracy; (4) ablative reentry vehicle development, which reduced payload weight and reentry dispersion, and increased accuracy; and (5) reduced thermonuclear warhead weight, which reduced payload weight, thus increasing range, for a given warhead yield.

ALCM key technology areas included: (1) a low specific fuel consumption, high thrust, small volume turbofan engine with high altitude startup, which increased range; (2) a

special warhead design; (3) a low observables air vehicle, using a special airframe, missile radar altimeter, and engine design, which increased survivability; and (4) terrain contour matching and terrain following software, which increased missile accuracy and survivability.

Missile Thrust/Weight Ratio

The initial thrust/weight ratio associated with engine propulsion, coupled with missile weight, proved to be optimistic for each program. This led to a decrease in range for the first wing of Minuteman I deployed and the Polaris A-1, and is indicative of an initial set of system requirements that exceeded the feasible level of performance that could be achieved for the estimated level of cost and schedule.

Sacrifices versus desired performance levels were made for each program in order to meet the initial deployment schedule. For the Minuteman I and Polaris A-1, a reduction in performance occurred along with an increase in development phase cost in the Minuteman I. Approximately 60 percent of the range reduction in the first Minuteman I wing was corrected in the second Minuteman I wing deployed in 1963, and virtually all of the Polaris A-1 missile range reduction was removed in the Polaris A-2 missile. The range (performance) reduction was accepted in the first Minuteman I and Polaris A-1 missiles deployed in order to reduce program schedule risk. In the ALCM case, no early attempt was made to correct the problem since the demonstrated performance level was adequate. The government emphasis in the ALCM program was to ensure the eventual production delivery schedule while maintaining development phase cost and performance.

Use of Parallel R&D

Parallel research and development (R&D) and simultaneous exploration of several alternatives were used extensively as risk reduction measures for selected key technology areas that required considerable advances in the state of the art. Parallel R&D had been recognized by this time as a key tool for reducing program risk when technology advances were required, particularly on a short schedule [34].

The extended parallel R&D present in the Minuteman I, Polaris A-1, and ALCM programs greatly reduced the resulting risk associated with the relatively short program schedule length, coupled with the technology development that was necessary.

For example, the Minuteman I program had as many as three different contractors developing missile propulsion stages during 1956-1961 [35]. The parallel R&D efforts were maintained until, and in the case of the third stage, after the program production decision in March 1960.

For Polaris: "In the launch area, 11 different methods of ejecting a missile from a submerged submarine were said to have been simultaneously considered. Similarly, in the navigation area at least two teams approached the problem of developing an inertial navigation system and several substitute navigation schemes were also explored." [36]

In the ALCM program, the engine and INE were well advanced in development prior to initiating the long-range ALCM program in January 1977. Each item had undergone parallel development with two contractors culminating with a selected design prior to beginning FSD. For example, the engine and INE downselect to a single development

contractor occurred in April 1973 and October 1975, respectively. However, the required ALCM deployment schedule necessitated increasing the production rate for the engine and INE. An identical design dual source production competition strategy was established during FSD for the engine and INE in August 1978 and October 1978, respectively, to meet the ALCM deployment schedule [37].

Development Phase Flight Tests

Although the Minuteman I, Polaris A-1, and ALCM programs had fast paced schedules, their early flight test programs were not particularly successful, and deployment occurred before the systems were fully mature. (Each system, though, still possessed moderate-to-high operational utility.)

Four of the first 10 Minuteman I flight tests (beginning February 1, 1961) were failures or partial failures. (In addition, the first Minuteman I flight was roughly 11 months after the initial production decision!) Flights of the first five Polaris-configured flight test vehicles (AX series, beginning September 24, 1958) ended in failures. Both the candidate Boeing and General Dynamics long-range ALCMs suffered four early terminations **each** in their 10 missile FSD flyoff (beginning August 3, 1979 and July 17, 1979, respectively).

Consequently, four or more of the first 10 flight tests were failures or partial failures for each program. In effect, the program managers and cognizant DoD personnel had considerable confidence in each weapon system, and protected them from adverse external reactions. Any DoD program today having a success factor of ≤ 60 percent in its first 10 flight tests, regardless of its flight test record afterwards, would almost certainly encounter considerable monitoring from external organizations (e.g., the Congress), that might adversely impact program cost, performance, and/or schedule, if not program termination.

Summary of Some Common Program Characteristics

At this point I will summarize some of the key characteristics of the Minuteman I, Polaris A-1, and ALCM programs discussed so far.

First, each program was a program of the highest national importance and held a BRICK-BAT DX priority rating. Second, each program was not wholly insulated from externally induced program impacts during the development phase. Similarly, the programs were impacted by service and DoD-level organizational and policy changes. Third, each program had only modest to moderate support until mid-way in the development phase. To a great degree factors external to the Minuteman I, Polaris, and ALCM program offices led to increased program support. Fourth, while each program received the necessary funding, potential funding shortfalls occurred that produced moderate program turbulence in the short run. In addition, the accelerated program schedules led to moderate development phase cost growth in the Minuteman I and ALCM programs. Fifth, each program required a moderate technology advance across the entire system, with a considerable advance in the state of the art required for only a few subsystems. Each program was the beneficiary of important advances made from prior technology or operational programs. Sixth, the initial thrust/weight ratio associated with engine propulsion, coupled with missile weight, proved to be optimistic. Seventh, parallel R&D and simultaneous exploration

of several alternatives were used extensively used as risk reduction measures for a number of the key technology areas. Eighth, the development phase flight test programs were not particularly successful. In today's acquisition environment, this would likely lead to program schedule slippage, if not termination.

CAN THE LESSONS LEARNED BE TRANSFERRED TO OTHER DoD PROGRAMS? (CONCLUSIONS)

Given the common characteristics of the three programs, I will now briefly discuss whether or not lessons learned from the Minuteman I, Polaris A-1, and ALCM programs can be transferred to other DoD programs.

First, the success of the Minuteman I, Polaris A-1, and ALCM programs was largely due to an unusual convergence of technological opportunities and a consensus on national needs.

The ballistic and cruise missile research programs had already made considerable strides in the technology associated with key subsystems for the Minuteman I, Polaris A-1, and ALCM prior to the FSD (equivalent) program phase. Hence, the underlying technologies needed for these missiles were already on the necessary path to yield viable subsystems.

In addition, there was a clear consensus on national needs associated with the perceived Soviet ballistic missile gap, coupled with the Sputnik program, that assisted both the Minuteman I and Polaris A-1 beginning in late 1957 [38].

As noted by Robert Perry, the Minuteman I and Polaris A-1 acceleration decisions were: "made feasible by the pace of technology--which certainly had been more rapid for ballistic missiles than for weapons contemporary with them. But the decisions probably would not have been made as they were if the Soviet Union had not provided first rate motivation: an unmistakable threat." [39]

Similarly, upgraded Soviet air defenses made the role of a long-range ALCM relatively more important than a short-range ALCM coupled with the B-1A penetrating bomber, that had less extensive stealth characteristics than either ALCM.

The breakthrough that permitted the rapid, extensive deployment of these missiles was far more political than technological. The political consensus permitted virtually unrestricted program funding, although moderate short run funding turbulence did exist, and diminished the influence of program critics.

In effect, the convergence of technological opportunity coupled with a consensus of national needs rarely has existed to the extent that it did for the Minuteman I, Polaris, and ALCM programs except for the Manhattan project, the Apollo project, and perhaps a few others. These were both fortunate and special programs in a number of ways, and although the technological advances made in each program were noteworthy, the political environment, defined through a consensus of national needs, that existed in each case played a dominant role in the development, deployment, and success of these systems. Without both technological opportunities and a consensus on national needs it is unlikely that many military programs run with a conventional acquisition strategy can achieve the accelerated (development) schedules typically associated with successful commercial programs.

In some cases a consensus of service needs may be sufficient, while for other programs, a consensus of DoD, government (including the Congress), or even national needs may be necessary to insure a successful program development and deployment in terms of the required performance and/or schedule.

As Harvey Sapolsky stated in 1972: "Most government undertakings, whether civilian or military, are apparently not the beneficiaries of a convergence between technological opportunities and political consensus." [40]

Second, of the eight common Minuteman I, Polaris A-1, and ALCM program characteristics previously identified only two are both desirable and somewhat within the control of the government program office director. These include the need for only a moderate average advance in the required technology state of the art and the use of parallel R&D for risk reduction (assuming adequate funding is available).

The other six items previously mentioned either require actions external to the government program office to implement (e.g., receiving a BRICK-BAT DX priority rating and service, DoD-level organizational and policy changes, and receiving necessary funding) or represent actions with potentially undesirable effects to the program (e.g., limited early support, optimistic missile thrust/weight ratio, and a not particularly successful development phase flight test program.)

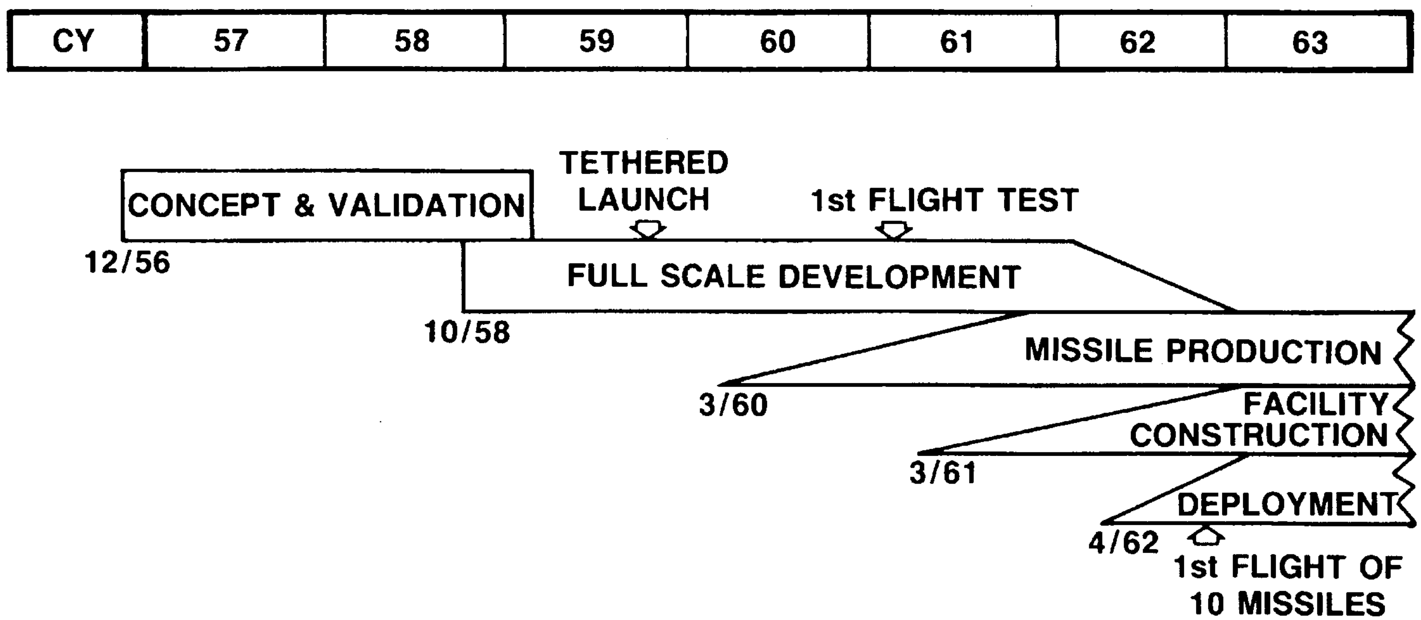
Consequently, applying lessons learned from the Minuteman I, Polaris A-1, and ALCM programs to a new military development program may assist the program to some extent (e.g., parallel R&D for risk reduction if funding is available). However, there is no guarantee that the program will achieve the same degree of success as in the Minuteman I, Polaris A-1, and ALCM programs. The level of success achieved by these programs was to a great extent determined by both necessary technological opportunities and a national consensus of needs which where external to the government program offices, and even the DoD itself.

ACKNOWLEDGEMENT

This paper is dedicated to the late Robert Perry, mentor and former colleague, who assisted me in the early stages of this research.

Minuteman I Schedule

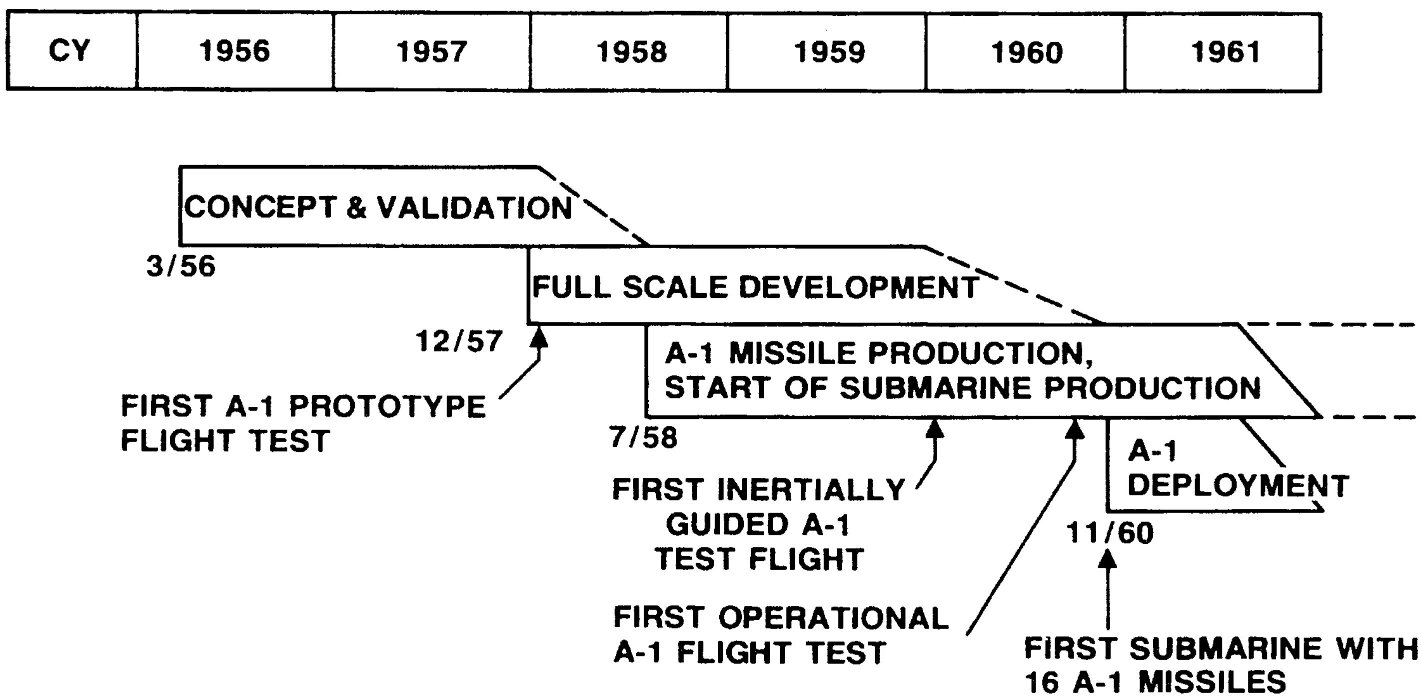
Figure 1



Source: Robert C. Anderson, "The Acquisition Process, Minuteman I-MX", TRW, Inc., August 1977, pg.26.

Polaris Schedule

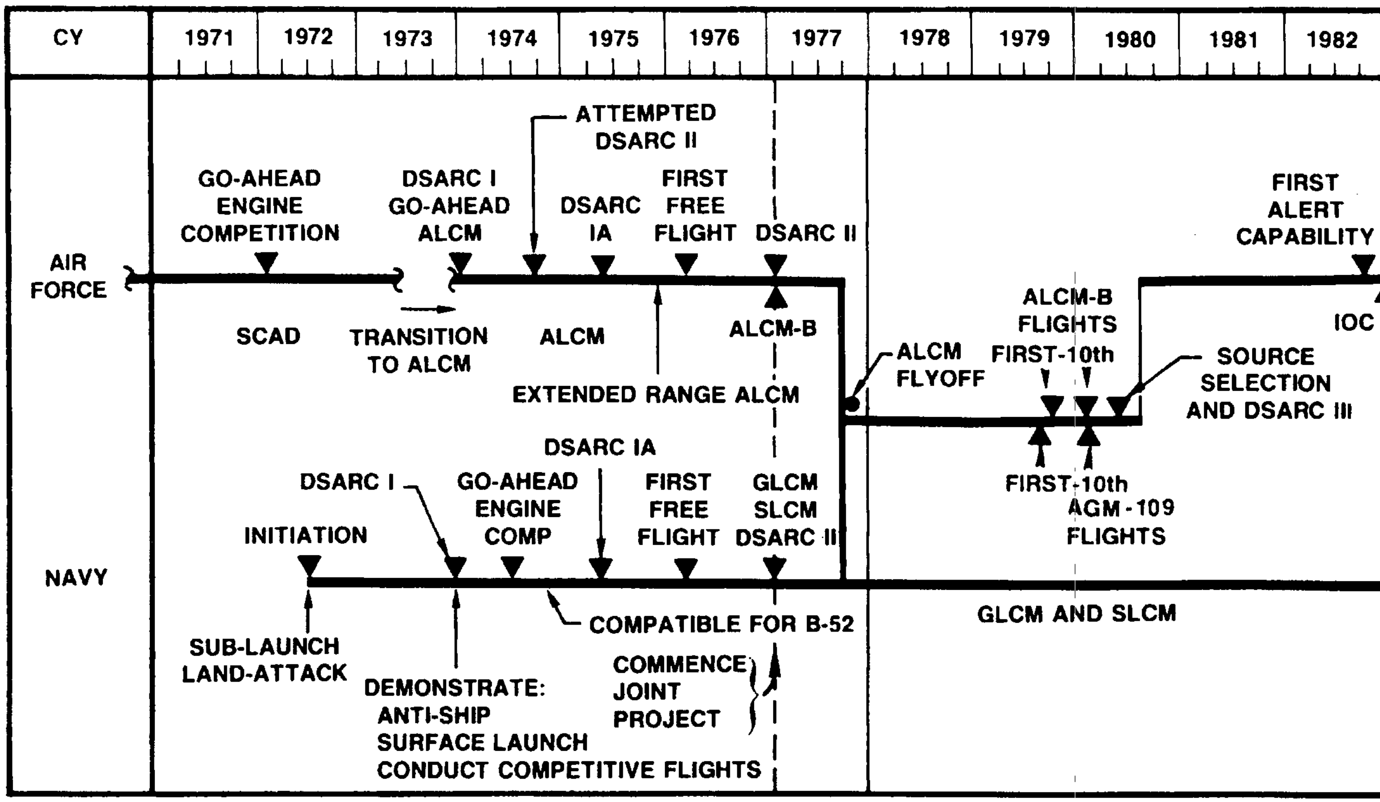
Figure 2



Source: H. M. Sapolsky, "The Polaris System Development", Harvard University Press, Cambridge, 1972; ______, "FBM Facts/Chronology: Polaris, Poseidon, Trident", Strategic Systems Program Office, 1986; and CAPT John Mitchell, Strategic Systems Program Office, private communication, January-March 1987.

ALCM Development History

Figure 3



EMPHASIS OF THIS ANALYSIS ON DSARC II (1/77) TO IOC PHASE

Source: Edmund H. Conrow, Giles K. Smith, and Allen A. Barbour, "The Joint Cruise Missiles Project: An Acquisition History", The Rand Corporation, R-3039-JCMPO, August 1982, pp. viii, 9, 11, and 62.

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SOME LONG-TERM ISSUES AND IMPEDIMENTS AFFECTING SYSTEMS ACQUISITION REFORM

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ABSTRACT

Over the past three decades, several approaches have been tried in an attempt to improve the predictability and control of military systems acquisition. Yet costs grow and schedules slip, while the final product usually has performance close to that specified.

The specific sources of cost and schedule growth may vary from project to project, but they are generally associated with the existence of different government program office and contractor objectives.

A microeconomic analytical framework was created to model the military systems acquisition process. The hypothesized model behavior is consistent with the statistical results obtained from analyzing the cost, performance, and schedule outcomes of a broad sample of military programs spanning the 1950s through 1980s. The same preferences, interactions and outcomes also apply to highly classified ("Black") programs and NASA space programs.

INTRODUCTION

The management of a major military system acquisition project is an exceptionally challenging task. Given its complexity, the large amounts of money frequently involved, and the political and military consequences riding on the outcomes, it is understandable that considerable attention and effort have been devoted to improving the methods of military systems acquisition management. Over the past three decades, several different acquisition strategies and numerous detailed management approaches have been tried in an attempt to improve the predictability and control of project outcomes. Improvements have been sought, for example, through changes in the types of contracts, the type and extent of competition, the amount of management reporting and review, and the distribution of responsibility between the service project office and industrial contractor. Yet the goal of a predictable and controllable project has proved elusive.

Persistent and widespread cost and schedule growth in U. S. military systems has been documented since the 1950s; in contrast, system performance is typically very close to desired levels. However, no satisfactory theoretical explanation has been advanced to date (1994) to explain this behavior.

While the specific sources of cost, performance, and schedule (C,P,S) difficulty may vary from one project to the next, they are generally associated with different preferences held by the government program

office and contractors, coupled with a poor understanding of the range of possible outcomes, which themselves are conditioned by program structure. A microeconomic framework is presented in this paper that addresses these issues and models the military acquisition process.

BACKGROUND

Marshall and Meckling were perhaps the first to identify cost, performance, and schedule as important variables for measuring program success [1]. They evaluated a sample of aircraft and missile programs with equivalent Engineering and Manufacturing Development (EMD) phase start dates in the 1940s and 1950s. They found the average ratio of the most recent and earliest production cost estimates to be between 2.4 and 3.2. (A ratio (change value) > 1 indicates cost or schedule growth or performance degradation.) This corresponds to a 140 to 220 percent increase in cost. They also found the average schedule change to be 1.5 between early estimates of first operational dates and the actual first operational dates.

Commenting on the cost growth and schedule slippage, Marshall and Meckling said: "Availability (schedule) predictions, like cost predictions exhibit both a decided bias toward overoptimism and substantial variation in the extent of the optimism." [2]

Perry, et. al. estimated cost, performance, and schedule change ratios for a sample of military programs with start dates in the 1950s and 1960s [3]. They found the average cost, performance, and schedule change to be 1.44, 1.05, and 1.15, respectively.

Dews, et. al. estimated these same ratios for a sample of military programs with start dates in the 1970s [4]. They found the average cost, performance, and schedule change to be 1.34, 1.00, and 1.13, respectively.

Cost and schedule growth occurred in each of these program samples, but where performance results were evaluated, virtually no change was observed.

Several insightful observations exist in the literature as to the causes of military system cost and schedule growth.

One likely cause was first identified by Marshall and Meckling in 1959: "Typically, in weapons development great emphasis is placed on performance. Most new weapons are developed around specific detailed performance requirements laid down by the military requirements that are taken very seriously. The penalties incurred by the contractors for not meeting performance requirements are more severe than for failure to meet availability schedules or failure to live within original cost estimates. As a result, whenever circumstances dictate a retreat from early plans, it is usually the costs and/or availability that gives ground." [5]

The government and contractors typically face only weak disincentives for developing unrealistic estimates of program cost and schedule, as identified by Marshall and Meckling: "Contractors are anxious to have their proposals accepted by the military, and the military itself is anxious to have development proposals supported by the Department of Defense and Congress. The incentive to make optimistic estimates is thus very strong. On the other hand, the contractual penalties for having been overoptimistic are generally small." [6]

The acquisition process of U. S. military systems has been distorted in this way for many years. Charles J. Hitch and Roland N. McKean stated it in the following manner in 1960: "Excessive optimism in drawing up performance specifications can make the development so difficult that it must fail, or take much longer and cost much more than planned, or require a downgrading of the requirements. It is not unusual for weapon system requirements to be so optimistic that several inventions or advances in the state of the art are needed on schedule if the development is to succeed." [7]

The Government Accounting Office (GAO) recently identified several issues that may lead to problems in major weapons acquisition, including: overly optimistic cost and schedule estimates leading to program instability and cost increases; programs that cannot be executed as planned with available funds; and programs being oversold to survive [8].

The GAO also attempted to identify possible causes for these problems, and stated: "While there are many reasons for these types of problems, the underlying cause of persistent and fundamental problems in DoD's weapons acquisition process is a prevailing culture that is dependent on generating and supporting new weapons acquisitions." [9]

In summary, distortions in the military systems acquisition process that can lead to considerable cost and schedule growth have been noted for the past 35 years and validated in part by data going back to the 1940s and 1950s.

Each of the above studies has contributed knowledge about military program C,P,S changes and some of their underlying causes. However, a void exists in the literature relative to a mechanism to tie cost, performance, and schedule trends together.

This paper presents a comprehensive microeconomic analytical framework that models the military systems acquisition process. It includes government and contractor preferences; external, programmatic, and technical constraints; factors that influence the program starting point; dynamics that occur during the course of a program; and likely outcomes predicted by the theoretical framework.

MICROECONOMIC FRAMEWORK

In acquiring U. S. military systems, the government and contractor each have a set of objectives regarding the projected C,P,S outcomes. The government generally prefers lower over higher cost and schedule, and higher performance, while the contractor prefers higher cost, performance, and schedule.

Lower costs are desirable to the government to develop more military systems for a fixed budget (or the same number for a reduced expenditure). Shorter schedules that enable the system to become operational earlier enhance the force structure and military balance of power. Higher performance permits increased operational capability for the mission.

Contractors prefer higher costs because they increase profits. Longer schedules are also desirable to maintain a stable work force and a long-term working relationship with the government, which gives the contractor a potential competitive advantage for follow-on or future contracts. Contractors prefer high performance to improve their potential competitive advantage in the high technology arena that often provides a potential competitive advantage.

The production schedule is generally set by high level government decision makers (e.g., the services or Congress), based upon inputs from the project office and contractors (e.g., cost versus lot quantity). Hence, the production schedule can generally be characterized as a constraint externally imposed by higher level government personnel.

Given the government and contractor preferences, the next step is to consider programmatic and technical constraints associated with cost, performance, and schedule.

The government will typically have in mind a maximum program cost and schedule length, along with minimum performance. The contractor will often have its own minimum cost and schedule length.

A technical possibility surface encompasses the region of feasible C,P,S solutions, and is the technical program constraint. Points on the technical possibility surface or any two-dimensional slice of the surface indicate efficient (but not necessarily optimal) solutions. (This is given by points B and C on the C:P possibility curve in Figure 1.) Points lying above a possibility curve indicate feasible, but inefficient solutions. Those points below a possibility curve indicate an infeasible solution. In Figure 1 for the C:P case (for a given schedule), point D above the curve is an inefficient combination of cost and performance, since the system could be developed at the same cost but with higher performance by moving to the right or at the same level of performance with less cost by moving down.

A point to the right of the C:P curve (A in Figure 1) is infeasible for a given set of input constraints (e.g., manufacturing processes, technology level, program structure) for a given schedule. This point will only become feasible with a shift to the right of the entire C:P curve, thus requiring, for example, improved yield for a given manufacturing process if cost is held constant. In effect, solution point A corresponds to an inappropriate schedule length selected for the specified cost and performance levels.

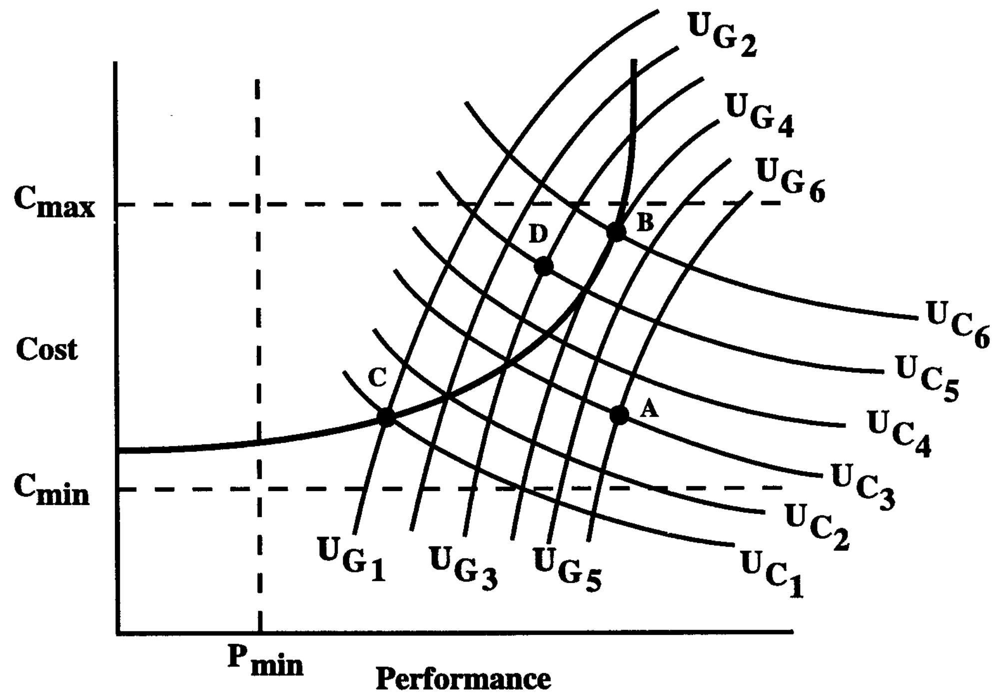
It is anticipated that the last few percent of the maximum performance possible will lead to increasingly greater program cost and schedule length (the first and second derivatives of cost with respect to performance are positive). This causes a major problem in military system acquisition where performance near or exceeding the current state of the art is typically specified for new development programs, yet insufficient cost and/or schedule is typically budgeted to achieve the desired level of performance.

The government and contractor preferences noted earlier typically lead to a sub-optimal solution since both parties jointly favor increased performance, but little pressure initially exists to prevent performance from dominating the resulting solution. The adverse cost and schedule of a performance dominated solution are often not recognized until relatively late in development when programmatic or technical constraints become evident.

Knowledge of the technical possibility surface, or even two-dimensional slices of the surface, may be unknown or highly uncertain for key subsystems. An uncertain technical possibility surface can lead to severe program risk when performance levels approach or exceed the highly uncertain state of the art, particularly when program cost and schedule characteristics are not considered in an unbiased fashion.

Overlaid, Constrained Typical Iso-Schedule Government and Contractor Cost:Performance Utility Curves and Technical Possibility Curve

Figure 1



Note: 1.) $U_{G_6} > U_{G_5} > U_{G_4} > U_{G_3} > U_{G_2} > U_{G_1}$

$U_{C_6} > U_{C_5} > U_{C_4} > U_{C_3} > U_{C_2} > U_{C_1}$

Where: U_G = government utility, U_C = contractor utility

2.) A = infeasible; B and C = feasible, efficient; and D = feasible, inefficient solution points

When ambitious performance requirements are set and the design process is dominated by performance, pressure exists on the government and contractor alike to meet these requirements, even if program cost and schedule are adversely affected as a result.

Government and contractor motivations to start and continue programs initially bias downward both parties' estimates of cost and schedule for a given level of performance, leading--later in the program--to increased cost or schedule in order to meet performance requirements. The issue faced by government and industry is how to adjust their C,P,S goals to be consistent with the technological possibilities that are being revealed to them.

By the time the problem usually is recognized a considerable investment has already been made in the system design. Hence, by this time the flexibility to alter the design by this time may be limited, leading to even greater cost or schedule growth than if the true situation had been recognized at the beginning of the program when performance requirements were specified and the C,P,S starting point was set.

Since both government and contractor utility decreases with lower performance, both parties may only reluctantly decrease performance requirements during development even when the originally chosen solution is infeasible. Hence, an unrealistic C,P,S starting point results in a C,P,S solution point that is not an unbiased or random choice between cost, performance, and schedule, leading to increased cost and schedule, but little decrease in performance.

If the C,P,S solution point lies in the infeasible region, such as point A in Figure 1, resolution of this unsustainable situation requires movement of the solution point to the north with generally increasing cost or schedule (point B, for example), to the west with generally decreasing performance (point C) or a combination of the two (between points B and C). Since the utility of both parties generally decreases with movement towards point C (less performance), this will not likely occur unless it is externally mandated. Hence, program change will tend to be towards the north rather than towards the west, bounded by the technical possibility curve: and the resulting solution point will also tend to be inefficient (e.g., lying above this curve, as point D).

Other movements from the infeasible to the feasible portions of the technical possibility surface are possible depending upon the position of the original solution point relative to the technical possibility surface. The key here is that the range of movement from an infeasible to feasible solution point will be limited by the relationship of "desirability regions" to the technical possibility surface.

The performance-driven choice process becomes all the more troublesome when the starting point is relatively high up on the technical possibility surface. Such a choice may cause large cost or schedule growth if the C,P,S starting point is unrealistic, particularly if impractical performance requirements are not relaxed. The resulting cost and schedule growth will generally lead to increased contractor profit. Since contractor utility increases with increasing profit, they have little reason to decrease cost and schedule, particularly when in a sole source role.

IS THE EVIDENCE CONSISTENT WITH THE THEORY?

Five hypotheses resulting from the microeconomic framework were tested and confirmed by a statistical analysis performed on a large sample of historic DoD programs. This statistical data analysis is the most extensive analysis ever performed on DoD C,P,S data. It also provides insights into the relationship between C,P,S variable trades for military program acquisition, and includes results using corrected Perry et. al. (1971) and Dews et. al. data sets.

Statistical analyses of C,P,S change data derived from DoD major weapon systems can help to determine the degree to which historical data are consistent with the microeconomic framework of military systems acquisition.

Three different data sets were obtained for the statistical analysis. The Perry data set was originally derived from surveys and follow-up visits to various DoD programs: it represents programs with Milestone II (or equivalent) dates in the 1950s (2 programs) and 1960s (18 programs) [3]. The Dews data set was derived from Selected Acquisition Reports (SARs), and represents programs with Milestone II (or equivalent) dates in the 1970s (18 programs) [4]. The Conrow data set was also derived from SARs, and represents programs with Milestone II (or equivalent) dates in the 1960s (7 programs), 1970s (17 programs), and 1980s (6 programs). The overall combined data set (1950s through 1980s) included 58 programs with 48, 52, and 51 programs reporting cost change, performance change, and schedule change data, respectively.

Summary descriptive statistics for the overall combined data set are given in Table 1. Sample statistics for all three data sets were quite similar, but since the overall combined data set covers a longer time period (1958-1986) and includes more systems, Table 1 only includes results from this data set. The mean, median, and standard deviation for the cost change and schedule change variables are similar to each other, yet noticeably larger than the corresponding values for the performance change variable.

C,P,S predictions, drawn from the microeconomic framework discussed above, were tested against the statistical results.

First Hypothesis: Because of government and contractor utility preferences, relatively few systems will have significant overall development phase performance degradations. In addition, since many U. S. military systems have performance requirements set at or beyond the technical feasibility level, relatively few programs will have large gains in performance from the initial estimated level.

The hypothesis cannot be rejected given the mean and median values for the performance change distribution, as well as the dispersal of performance change values around the no change level (1.00). Both the mean and median values for the performance change distribution were 1.00, and only 10 of 52 programs had a slip in performance > 10 percent while only 9 of 52 programs had a gain in performance > 10 percent.

In terms of more extreme values, only two of 52 programs had a slip in performance of 25 percent or more, and only one of 52 programs had a gain in performance of 25 percent or more.

OVERALL COMBINED DATA SET SUMMARY STATISTICS (*)

TABLE 1

Variable	**COST**	**PERFORMANCE**	**SCHEDULE**
Sample size	48	52	51
Average	1.26	1.00	1.24
Median	1.16	1.00	1.13
Standard deviation	0.28	0.13	0.30
Minimum	0.86	0.65	0.75
Maximum	2.07	1.42	2.25
Lower quartile	1.06	0.92	1.03
Upper quartile	1.41	1.06	1.44
Skewness	1.24	0.38	1.24

*: Cost, performance, and schedule correspond to cost change, performance change, and schedule change associated with the current program estimate divided by the initial Milestone II (or equivalent) estimate

Second Hypothesis: Due to a combination of utility preferences and technical feasibility, the variation in performance change for U. S. military systems is likely to be smaller than corresponding variations in cost and schedule.

From Table 1, the standard deviations of changes in cost, performance, and schedule are 0.28, 0.13, and 0.30, respectively. Consequently, the hypothesis cannot be rejected given that the standard deviation of performance change is less than half that of program cost change and schedule change.

Third Hypothesis: Due to a combination of utility preferences and technical feasibility, U. S. military systems will typically exhibit an increase in cost and/or schedule during development.

The hypothesis cannot be rejected given that 43 of 48 programs (90 percent) exhibited cost growth and that 40 of 51 programs (78 percent) exhibited schedule slippage. In addition, a number of programs had large cost growth or schedule slippage. For example, 30 of 48 programs had cost growth ≥ 25 percent and 20 of 51 programs had schedule slippage ≥ 25 percent.

Fourth Hypothesis: The shape of the development performance distribution will likely be near-symmetrical, whereas the shapes of the cost change and schedule change distributions will likely be right-hand skewed. This is because the government and contractor strive to meet performance requirements, while typically adjusting program cost and/or schedule to achieve the desired levels of performance. Final performance achievements can be viewed as random variations around the target value.

The hypothesis cannot be rejected given the skewness, mean, and median values for these change distributions in Table 1. A skewness of 0 indicates that the data are symmetrically distributed while a positive

value indicates that the distribution has a right-hand skew. From Table 1, the skewness coefficient for the cost change and schedule change distributions is positive and roughly 3.3 times greater than that for the performance change distribution. In addition, the skewness coefficient for the performance change distribution is near zero (0.38).

The difference in the mean and median for the performance change distribution is virtually zero, while that for the cost change and schedule change distributions are 0.10 and 0.11, respectively. These results, as with the skewness results mentioned above, indicate that the performance change distribution is nearly symmetrical, while the cost change and schedule change distributions have a right-hand skew.

The initially infeasible C,P,S solution point that exists for many systems results from a mis-specification of the technical possibility surface due in part to an underestimation bias associated with the level of performance that can be achieved for a given level of cost and/or schedule. This together with the primary government and contractor desire to meet performance requirements, while allowing cost and/or schedule to increase during the course of the program to achieve a feasible C,P,S solution point, causes the cost change and schedule change distributions to have means greater than one, as well as a right-hand skew.

Fifth Hypothesis: Given the complex nature of the C,P,S trades that occur during a military program, no simple relationship will likely exist between the Milestone II date and C,P,S change.

There was negligible correlation between cost change, performance change, and schedule change versus the Milestone II date. Consequently, the hypothesis cannot be rejected given the limited correlation between C,P,S change and the Milestone II date.

DISCUSSION AND CONCLUSIONS

The above results support the contention that various military systems acquisition policy changes instituted by the government have had little success in dealing with the underlying issues discussed above that contribute to program cost and schedule growth.

Although the average cost growth for the overall combined data set is 26 percent, the dollar magnitude of military program cost growth is also important.

It was only possible to confidently identify the dollar magnitude of cost growth for the Conrow 30 program data set. Initial EMD phase cost estimates for the Conrow data set were compared to actual values recorded following the completion of this program phase.

The resulting total cost growth of this sample was $10.9 billion (FY94). When projected to all military development programs over the past 35 years, including Concept Exploration and Definition and Demonstration and Validation phases in addition to the EMD phase, the resulting total development cost growth is likely between $40 billion and $80 billion (FY94)! (In addition, substantial production phase cost growth has also occurred during this time. Production phase cost growth is often, at least partially, driven by the microeconomic inefficiency of the development phase C,P,S solution point.)

While it is easy to identify the cause of performance-related problems in the DoD

systems acquisition process, it will be much more difficult to create a paradigm shift to deal with it due to the underlying incentives that are inherent in the institutional structure. Having a set of C,P,S analytic trade tools early in the program design process may aid decision makers in making rational decisions. However, simply possessing viable trade tools will not be sufficient to eliminate the problems discussed above for two reasons.

First, all military programs have C,P,S risk due to an incorrectly specified technical possibility surface, which results from uncertainty in specifying the surface coupled with institutional biases and preferences. Having C,P,S trade tools or risk assessment tools does not guarantee that they will be applied in an unbiased fashion, particularly since both the government and contractors routinely underestimate the risk present in military programs [10] [11].

In the worst case the estimated program risk is intentionally biased downward in an attempt to portray the program in a more favorable light with higher level government personnel. In effect, there is typically little or no reward in most military programs for identifying relatively high risk items in the early development phase and furnishing the information to higher level government personnel, since it increases the odds of adverse impacts on personnel, funding cutbacks, or program cancellation.

Second, the government and contractor decision makers are typically "graded" much more strictly on whether or not program performance objectives are met versus meeting cost and schedule objectives.

Identifying and managing prospective cost drivers and trading-off schedule in an attempt to manage risk is currently required by DoDD 5000.1, but it is insufficient given the distorted nature of military program cost and schedule versus performance preferences that exist [12].

The wide spread cost and schedule problems caused by the development of performance-driven military systems will not be eliminated by new acquisition trends, such as concurrent engineering and total quality management, unless they are specifically re-oriented to address the changes needed to correct underlying government and contractor institutional biases, preferences, and interaction dynamics, coupled with an uncertain technical possibility surface.

In summary, placing equal or near equal emphasis on meeting program cost and schedule, as well as performance objectives, will be necessary in order to eliminate the strongly ingrained government and contractor program management bias favoring performance that has existed for at least the last 35 years in U. S. military systems. This is particularly important given the substantial dollar magnitude associated with cost growth during this time. No appreciable change in program outcomes is likely to occur without a re-oriented C,P,S emphasis.

The economic theory and statistical results in this paper directly address government and contractor preferences, interactions, and outcomes for the United States DoD systems acquisition process. The same preferences, interactions and outcomes also exist for highly classified ("Black") programs, as well as NASA space programs, given the structure of their acquisition process. For example, the GAO found "no major difference between the cost, schedule, and performance results of the special access acquisition programs it sampled and those of non-special access DoD programs" [13].

The GAO also found considerable cost and schedule growth for mature NASA space vehicle programs [14]. Similar preferences, interactions, and outcomes also likely exist for performance-driven large-scale civilian programs (e.g., megaprojects) [15] [16].

The economic theory presented in this paper can be adapted to represent the military or commercial systems acquisition process of other countries. For example, the microeconomic framework has been applied to the former Soviet Union military systems acquisition process. Extension of the microeconomic theory to predict likely systems acquisition outcomes for other countries, such as Japan or Sweden, can be readily accomplished given a modest amount of information.

ACKNOWLEDGEMENT

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DISCLAIMER

This paper is based upon independent research conducted by the author during 1981-1994. The views expressed are those of the author and not necessarily those of the United States government or any of its agencies.

F-15 INTEGRATED WEAPON SYSTEM MANAGEMENT "IWSM"

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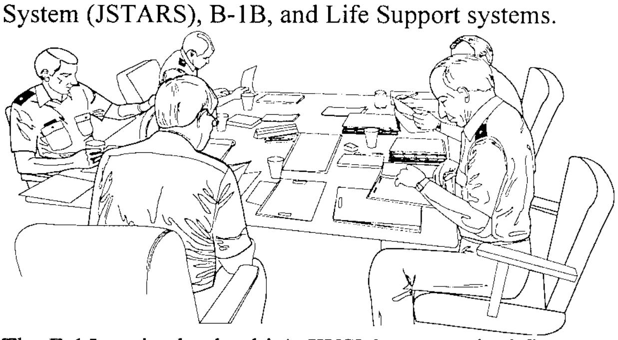
F-15 Strategic Planning and Integration Division

ABSTRACT

The F-15 program was one of several programs selected to prototype the Integrated Weapon Systems Management (IWSM) concepts. This paper will discuss how the F-15 lead the initiative for integrating the Air Force Systems Command (AFSC) and the Air Force Logistics Command (AFLC) organizations into IWSM under the new Air Force Materiel Command (AFMC). Since the inception of IWSM, the F-15 has served as the benchmark for other IWSM organizations to emulate as a result of outstanding success.

The Inception

In 1991 the F-15 took-on the role of lead platform for integrating Air Force Systems Command (AFSC) and Air Force Logistics Command (AFLC) organizations into Integrated Weapon System Management (IWSM) under the new Air Force Materiel Command (AFMC). The two commands were previously responsible for research, development and acquisition by AFSC and logistics support and sustainment for operations by AFLC. The concept of operations employed for a successful merger is known as Integrated Weapon System Management (IWSM). Under the IWSM, AFMC presents a single face to the warfighters/user and would be responsible for cradle-to-grave management of weapons. The F-15 program was one of several programs selected to prototype the IWSM concepts; the other programs included AGM-65 Maverick, Navstar Global Positioning System, Joint Surveillance and Target Attack Radar System (JSTARS), B-1B, and Life Support systems.



The F-15 senior leadership's IWSM strategy had five overarching tenets:

a) Bring together the talents and capabilities of both acquisition and sustainment communities of the System Program Office (SPO);

b) Improve business practices by integrating management processes;

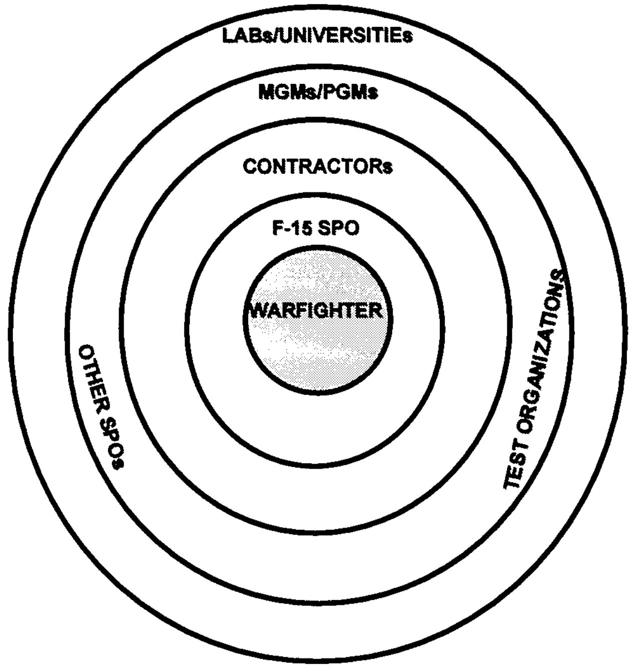
c) Establish clear lines of accountability and responsibility;

d) Institutionalize a cradle-to-grave management concept across the SPO;

e) Provide a single face to our warfighters .

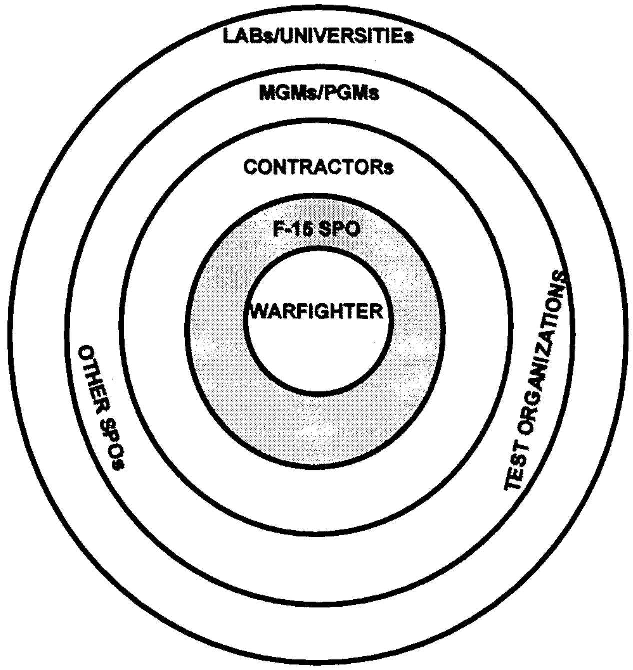
The senior leadership felt the key to satisfy these tenants was to organize into product and process-focused teams, and to develop and execute an F-15 Master Plan. In March 1993, the SPO officially declared IWSM full operational capability. During the initial phase, several automated tools were developed and deployed; the tools tie the acquisition and modification programs to the Programmed Depot Maintenance (PDM)/ retrofit programs, and provide options to make F-15 post production support strategies/decisions

Since the inception of IWSM, the F-15 has served as the benchmark for other IWSM organizations to emulate as a result of our outstanding success. Today, we continue to be structured as one organization, operating out of two geographically separated locations, led by the single manager-- the F-15 System Program Director (SPD). As the single manager, the SPD is responsible for all facets of acquisition and sustainment (cradle-to-grave management) of the total F-15 weapon system which includes three major product groups, the F-15A-D (Air to Air), the F-15E (Air to Ground), and Foreign Military Sales (FMS). Everything from nuts and bolts, to avionics, to engines, to landing gears, to support equipment and trainers--all fall under the SPDs Area of Responsibility (AOR). Many of these items or subsystems are managed by other Product Group Managers (PGMs) or Material Group Managers (MGMs) located at other AFMC bases or Defense Logistics Agencies. For instance, engines are managed at San Antonio ALC, while landing gears are managed at Hill AFB. The bottom line is: If they are attached to the F-15, then the SPD has oversight.

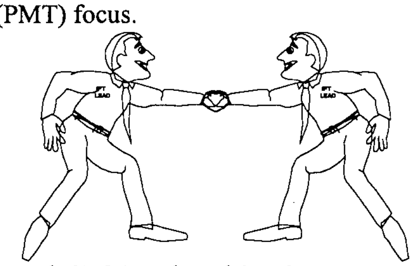


The Team Eagle

The SPD is the single face to the customer which in the F-15's case is the Combat Air Forces (CAF) which consists of Air Combat Command (ACC), USAF in Europe (USAFE) and Pacific Air Forces (PACAF), Air Education and Training Command (AETC) and the Air National Guard. The F-15 is currently flown by 21 USAF and National Guard Bureau (NGB) units and three foreign countries--Saudi Arabia, Israel, and Japan. The United Arab Emirates (UAE) is also considering entering the realm of the F-15. One of our foreign customers (Japan) has the ability to produce their own F-15s. The SPO is very sensitive to the customers' needs and desires and therefore maintains very close communication with them on all aspects of F-15 acquisition and sustainment issues.

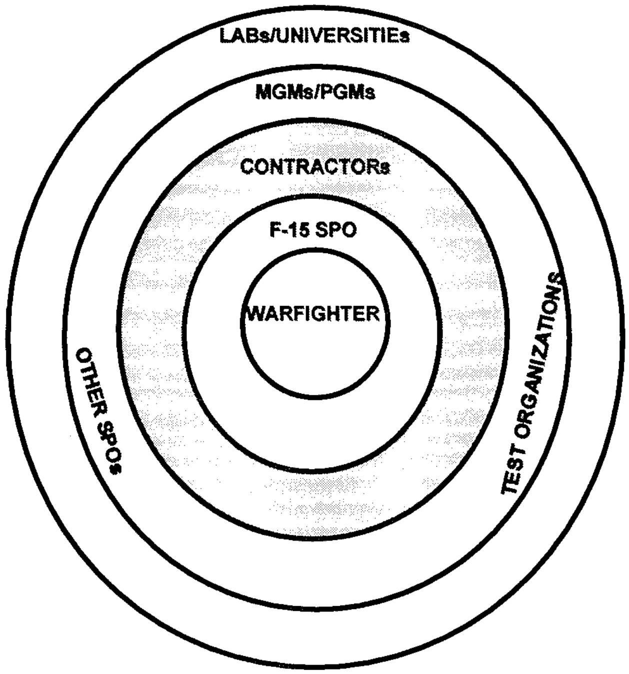


Prior to IWSM, the F-15 program had an AFSC office at Wright-Patterson Air Force Base, which managed the acquisition of the F-15E and new capabilities; while an AFLC office at Robins AFB managed the day-to-day support and modifications to the F-15 A-D fleet and two foreign military sales offices at both locations. The success of F-15 IWSM has been a direct result of our Integrated Product Team (IPT) and Process Management Team (PMT) focus.



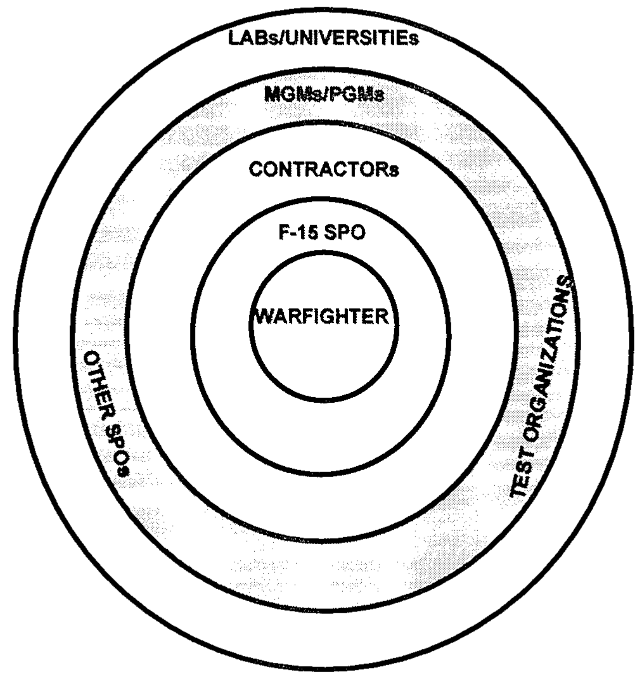
Even though SPO North and South are currently organized differently and in different geographic locations, they have a common bond which is the IPT and PMT process. These IPTs and PMTs are made up of functional experts (program management, engineering hardware and software, financial management, manufacturing, configuration control, contracting, production, etc) from each location. Leadership of the IPT or PMT is dependent upon the major focus for that effort . If it is a new acquisition, chances are SPO North will retain the leadership of the team. If sustainment is the driver, SPO South is more likely to be designated the lead. Regardless of whether North or South leads the team, there will be a co-lead at the opposite location. This ensures that ownership of the project is shared by both

locations and all possible functional specialties have an opportunity to provide value added inputs.



Very important to Team Eagle's success is the team of contractors, vendors and suppliers that have designed, supported, and redesigned the F-15 throughout its lifetime. The prime contractor for the F-15 is McDonnell Douglas Aerospace East (MDA-E), located in St Louis Missouri. In concert with MDA-E are numerous significant others to include: Northrop/Grumman with electronic warning systems and test equipment; Pratt & Whitney with engines; Loral, with avionics subsystems; Hughes for the radar, and Honeywell and Litton with navigation systems. The SPO believes very strongly that in order to survive the severe cuts in funding and manpower going on everywhere, the entire F-15 Team (Government, the Warfighter, Industry, Educational Institutions) must work closely together to keep the jet flying. As a result, industry has become an active and recognized member on our IPT teams. This membership is key to recognizing and acting on, to-date, untapped resources and opportunities which must be exploited to keep the Eagle viable in today's environment.

Continued nurturing of the SPO/Contractor relationship will hopefully develop improved means and processes to procuring required services and equipment. Certainly, the existing system is much too oversight intensive, resulting in high costs to manage and field a system both in respect to time and funding. Improved relationships with our contractors will only serve to strengthen our already outstanding ability to keep the jet flying.



As mentioned earlier, the F-15 is made up of numerous subsystems many of which have common applications with other weapons platforms. Often these common items or materials are managed by a centralized product office as opposed to each weapons platform managing their own requirements and therefore duplicating efforts and missing out on economies of scale. These product-oriented organizations are referred to as Materiel Group Managers (MGMs) and Product Group Managers (PGMs)--examples of which are engines, landing gear, tires, and fuels just to name a few. Because of the wide dispersion of workload throughout AFMC, virtually every air logistics center and product center plays a major role in the modernization, supply and support of the F-15.

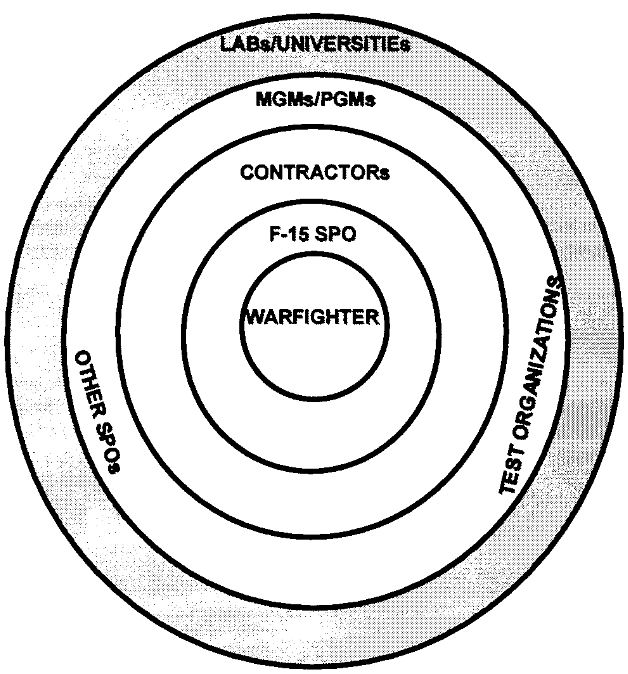
The MGMs and PGMs are obviously key members to Team Eagle. This is understandable as we're sure you have already figured out--F-15s don't fly nearly as long or land as well if they don't have engines, fuel or tires.

As single manager, the F-15 SPD must stay in touch with all the systems and products associated with continued support of the eagle. The SPD's main forum for discussion of these issues is through semi-annual System Supportability Reviews (SSRs). In this forum, PGMs and MGMs are invited to discuss any problems experienced

on their programs where SPD involvement or knowledge is required. In many cases, the SPD can communicate these issues to higher headquarters more effectively than the MGM or PGM. Therefore, it is extremely important that both the MGM/PGM and SPD are telling the same story as to the health of a particular system or project. Forums with high levels of attention to which the SPD has access include the Weapon System Performance Assessment Reviews (WSPAR) and the Combat Operational Readiness Reviews (CORR), each given yearly.

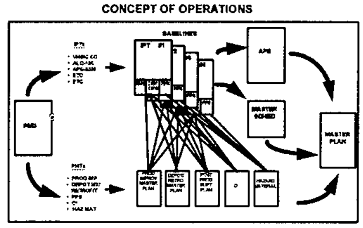
Modernization efforts are located at other product centers but provide new capabilities to the F-15. For example, Electronics System Center (ESC) provides the latest mission planning capability and electronic warfare items; while the Space Systems Center (SSC) provides Global Positioning System; Human Systems Center (HSC) provides upgraded aircrew equipment capabilities.

In short, MGMs and PGMs play a very important role in keeping the Eagle flying everyday. Our continued team interaction and communication is fundamental in keeping this capability going strong. The F-15 SPO is aggressively pursuing enhanced partnerships and improved communications as integrated product development (IPD) continues to grow.



One of our quiet and little known team members are the many private and Government Laboratories and Universities which play an important role in F-15 supportability. These organizations work on the leading edge of technology that is so critical to the success of an electric jet such as the F-15. As older technologies become obsolete, newer technology applications become critical in order to ensure continued operational capability of the jet. One method to stay abreast of the emerging technologies is through the technology planning IPT, or TPIPT. The TPIPT briefs program offices on a regular basis to either gain support for a research effort or gain insight from the SPO about their new problems. This process is healthy for all involved; it now includes the warfighter--who supports those technologies that bridge gaps in the users mission area plans. Other virtual team members include Air Force Flight Test Center (AFFTC), AEDC, and the Air Force Development Test Center (AFDTC). That's TEAM EAGLE!

CONCEPT OF OPERATIONS



F-15 System Program Office Concept of Operations

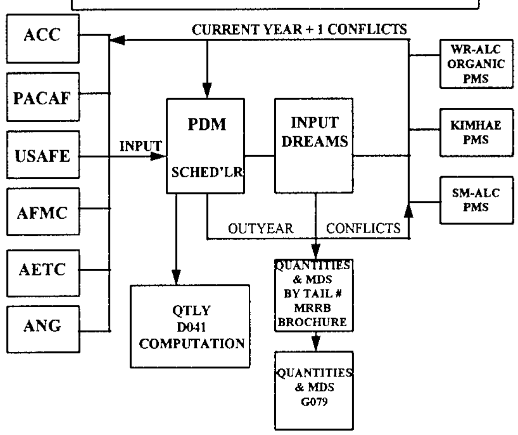
- Integrated product teams (66) and process management teams (5)
  - Across all disciplines/all locations
  - Based upon PMD direction
  - All IPT projects baselined
  - All PMTs with plans
- Master Plan
  - Rolls up IPT baselines
  - Includes major process plans/master schedules
  - Basis for SPO operations/reporting/metrics

Single Manager Concept of Operations (CONOPS)

Remember, the F-15 SPD is the single point of contact for the customer and is the single voice for the F-15 SPO, but can delegate within the SPO community to interface with the various Centers/Commands to support the F-15 mission.

When the team was formed, business practices and processes needed to reflect the single management concept. Process Management Teams (PMTs) were formed to define, review, document and continually fine tuned the critical processes. There were currently five PMTs for Programmed Depot, Post-Production Support, Product Improvement,Commodity Class Consignment, & Hazardous Materials.

F-15 PDM SCHEDULING PROCESS

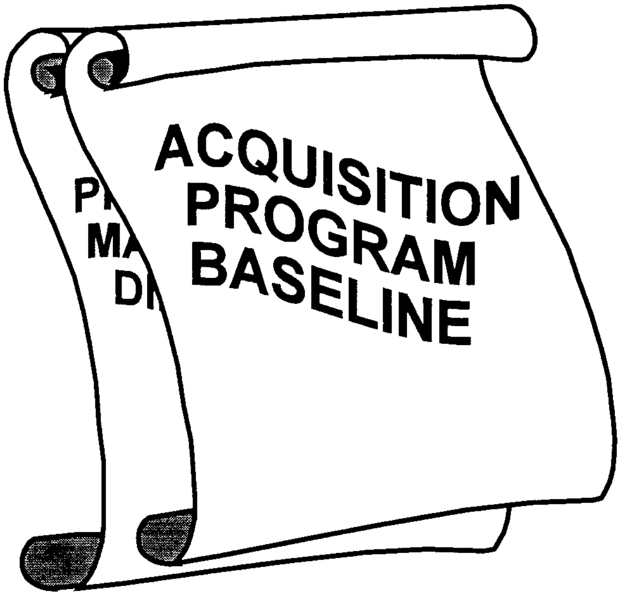


To date, 15 key Single Manager processes have been mapped. The processes are provided to the workforce through monthly orientation classes taught by process owners and experts.

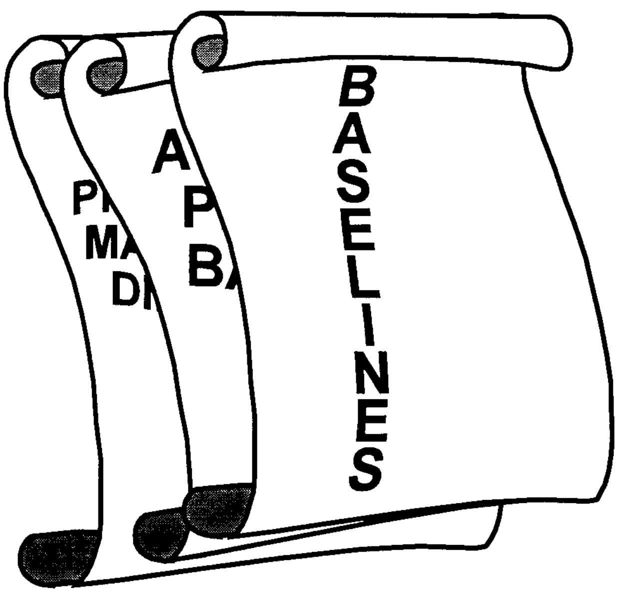
SINGLE MANAGER KEY PROCESSES

- COST ESTIMATION
- OBLIGATION FORECAST
- BUDGET
- COST MANAGEMENT
- SCHEDULING
- ECP/CCP
- HUMAN RESOURCES MGT
- SYSTEMS ENGINEERING
- SYSTEM FIELDING
- BASELINES
  - ✓
  - ✓
  - ✓

The F-15 SPD recognized that doing business in the new IWSM environment required changes at all levels of Air Force. One of the first opportunities to make change was to replace the old Program Management Directive (PMD) with one that reflected an integrated weapon system management (IWSM) approach for the development, support and continued enhancement of F-15A-E combat capability, readiness, and sustainability. The PMD outlines current and planned products and projects. Specific products/projects contained in the F-15 PMD are used to build the F-15 APB. Therefore, the next challenge was the Integrated Acquisition Program Baseline (APB). The APB contains key performance, schedule, and cost parameters which are the basis for satisfying an identified mission need. It is designed to enhance program stability and control cost growth. The APB is a summary and does not provide detailed program requirements or content.

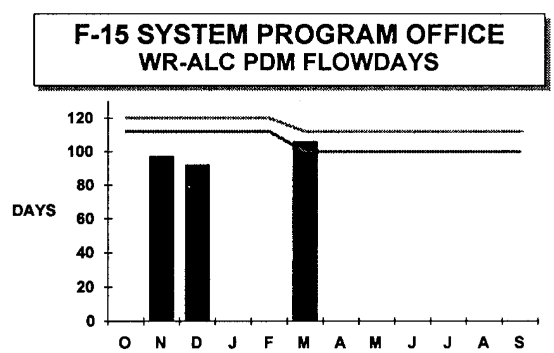


However, Product/Project Baselines do contain detailed information about the project, such as cost, development and installation/retrofit schedules, technical performance measures that address the various "cradle-to-grave activities"; other affected subsystems, contrators, and IPT members. All IPTs are responsible for baselining their efforts. The baseline is the management tool to define the project and to provide traceability to the F-15 APB, and is reviewed and scrubbed by the configuration control board before being approved by the SPD. The baselines are a contract between the SPD and the IPT. With an approved baseline, an IPT is empowered to manage and execute it. This project ownership produces the synergy that creates a seamless, single management, IWSM organization.



Teams make it happen.
The IPTs will maintain close control of the most important and time sensitive elements within the program. As stated earlier, IPTs are the foundation of F-15 single management concept. IPTs bring together the required functional development and support expertise by working among and across organizational lines to execute early development, modification, or support programs. IPTs follow the principles of integrated product development. Their focus is on a specific development, integration and support product which demands the expertise of many, if not all, functional areas at both the product and logistics centers as well as appropriate membership for organizations external to the SPD.

Recently, a new IPT was created to instill robust, clear communications (across all product and process teams) from cradle to grave to ensure compatibility of all physical, functional, and program interfaces in a manner that optimizes the total weapon system performance. The Systems Integration Product Team (SIPT) will also promote systems integration advancement through continued process definition and improvement. The SIPT owns the single manager's key processes and serves as the "real estate agent" and "traffic cop" for the SPD. They will transform operational needs into a description of system requirements and allocate those requirements to optimize the overall system effectiveness. The SIPT's principle customers are the product-focused IPTs who have ultimate responsibility to execute their baselines.



		O	N	D	J	F	M	A	M	J	J	A	S
ACTUAL		0	97	92	0	0	106	0					
PLANNED		120	120	120	120	120	112	112	112	112	112	112	112
# ACFT PROD		0	0	2	2	0	1	0					

Another type team was formed at the depot operations at Robins Air Force Base. They are known as work center quality teams (WCQTs) as well as a "natural team" because they are made up of a supervisor (Team Leader)

and all employees (Team Members) that are assigned to that supervisor. A WCQT works on problems or improvement opportunities of its choice within its process (work environment) by identifying constraints and working to improve quality, increase productivity, enlarge capacity, decrease scrap and rework, and/or reduce cost. A WCQT will always be active. Once the team has achieved an objective and/or submitted recommendations, it will initiate another objective (continuous improvement within the process). Membership is automatic and results from being assigned to applicable work center.

An excellent example of Virtual SPO Teaming was the Desert Eagle Team that was formed during Desert Shield/ Storm to solve severe F-15E supportability problems. This team was made up of members from SPO (N&S), ACC, LG staff and the Senior Leadership of out prime contractors (MDA, Hughes, ETC.) and chaired by the SPD. Under the umbrella of this team were sub-teams working issues like radar supportability, targeting pod shortages, weapons release problems, windshield erosion, and electonic countermeasure software. The pay off was record high aircraft availability, mission capability and combat effectiveness.

Tools

The set of automated tools to aid in the "cradle-to-grave" management of the F-15 is known as the EAGLE Toolbox. The Toolbox contains several automated tools that enhance our ability to manage our depot retrofit program, to make informed post production support (PPS) decisions and etc. Depot Retrofit Event and Modification System **(DREAMS)** provides on-line visibility on each F-15 aircraft's PDM workload, modifications, and repair and configuration status.

Our PPS tools are the greatest thing since "crushed ice". One cool tool is Tooling Disposition Decision System **(TDDS)** uses prime manufacturers data to match each part with the production tooling, then provides a post production support recommendation on the retention/disposition on the tooling. The Brother tool to TDDS is **TIMS**, or Tooling Inventory Management System, which ensures that all production tooling has an account that addresses the tooling function, usage rates for spares, location, storage requirements.

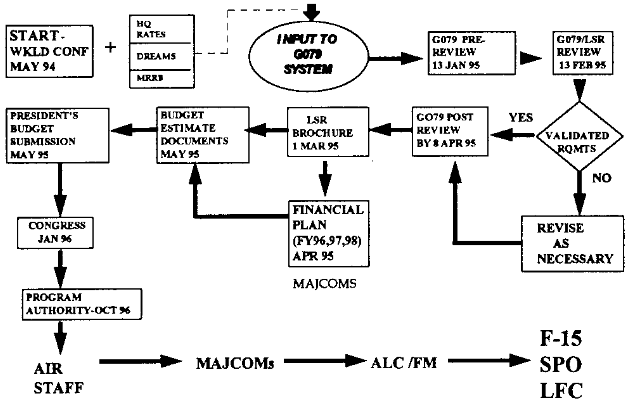
The cradle tools in EAGLE Toolbox support requirements identification, program and item management and program execution. The initial requirements identification process is supported by the Modification Initiatives Management System **(MIMS)** which documents, displays, and supports the Quality Function Deployment (QFD) process that establishes priorities for product improvement initiatives. Automated Program Management System **(APMS)** allows project managers to define and report on their critical program milestones, key parameters, and funding requirements and disconnects. Candidate Parts List **(CPL)** is the repository and database for all F-15 parts data, to include National stock Number, Part Number and Cage code for current and future support capability.

EAGLE Toolbox has received a lot of notoriety of late. Boxscore winner at WR-ALC in Nov 94, one of General Yates', Commander of AFMC, "Great Ideas" for 1994 and a selected topic at the Fall Single Managers Conference. The Navy also thought it was a great idea and are in the process of importing several of the tools to their PPS plans for the EA-6B and F-14 weapon systems.

DREAMS, MIMS and APMS are invaluable when we prepare to get buy-in from the warfighters on our programmed depot maintenance (PDM) schedules. There are two significant mandatory forums where we present our schedules and work packages to our customers and HQ AFMC representatives--the Maintenance Requirements Review Board (MRRB) and Logistics Support Review (LSR).

At the MRRB, we present the organic and contractor workload that we envision for the next two years. These work requirements define the tasks that are to be accomplished during PDM, Analytical Condition Inspections, speedlines or by contractor field teams. The process is a continuos two-year projection of workload that is refined annually by the board; the packages are reviewed on a quarterly basis The MRRB is chaired by our customer with HQ AFMC serving as an advisor. The result is an approved workload package for the two subsequent years.

G079 FLOW PROCESS CHART



The LSR is conducted yearly and is led by our customers with Air Staff and HQ AFMC overseeing the process. Our major command customers now have budgeting responsibility for our Depot Purchased Equipment Maintenance (DPEM) requirements. At the review, DPEM requirements from the G079--System & Equipment Modification/Maintenance Program(SEMMP)--system are validated. The workload requirements are based on the DREAMS (schedule), MRRB hours, and approved hourly rates. The LSR looks at a three year window of requirements and allows the customers to submit their requirements into the three year Financial Plan for the Budgeting Estimate Submission to Congress. This process provides the ALC the dollars necessary to perform the workload, whether it be contract/organic, Depot Field Team (DFT)/Contract Field Team (CFT) workload.

One year ago, the F-15 SPO initiated a forum known as the Aircraft Configuration Management Review (ACMR). The ACMR is the result of a fighter wing's realization that the downtime associated with accomplishing Time Compliance Technical Orders (TCTOs) adversely impacted their flying program objectives. Team Eagle analyzed the circumstances and reengineered their TCTO process--instituted the ACMR process. The ACMR takes a 18-month forward look at the TCTO efforts, to include validation and verification milestones for those programs in the queue. Superintendents from each fighter wing and HQ ACC logisticians, along with our production planners, logistics/program managers review and synergize TCTO work packages. Even though the process is young, it has already reaped dividends through improved communications with the warfighters about aircraft downtime.

In the forementioned cases, the warfighters get the opportunity to review our work packages, rates and schedules before hand, work the hard issues at the grass roots level and we obtain relatively easy buy-in by senior leadership.

All good teams have a vision, the team developed the following:

F-15 TEAM EAGLE VISION

- **The 21st Century F-15 Eagle will be operationally effective, affordable, and sustainable in support of the Air Force Vision and U.S. National Security objectives.**
- **The F-15 will always be a fighter that has the total confidence of the warfighter allowing the Eagle to fly, to fight, to win, and to return home--every time.**
- **The people of Team Eagle care about each other. We maintain the highest standards of safety and quality from start to finish--because what we do is important. *In spirit, we all fly with the Eagle on each mission.***

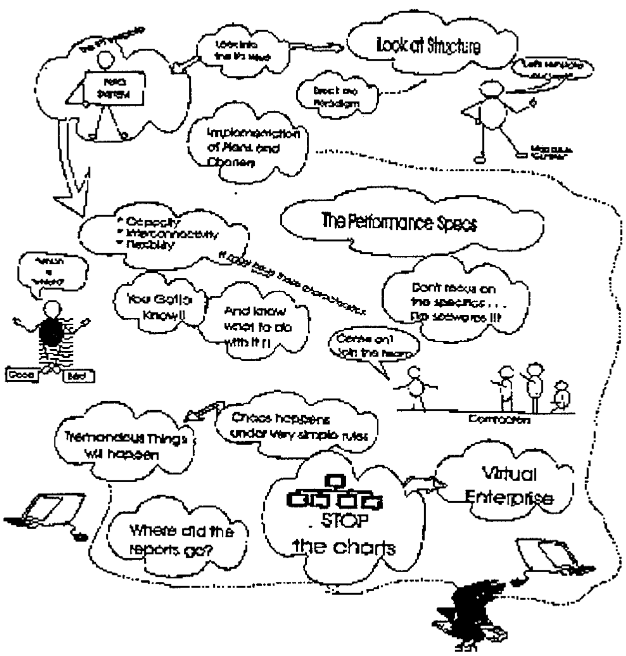
F-15 EAGLE DAILY GOAL

Team Eagle Strives each day to develop, sustain, maintain, and fly the highest quality fighter at the lowest possible cost.

F-15 TEAM EAGLE MOTTO

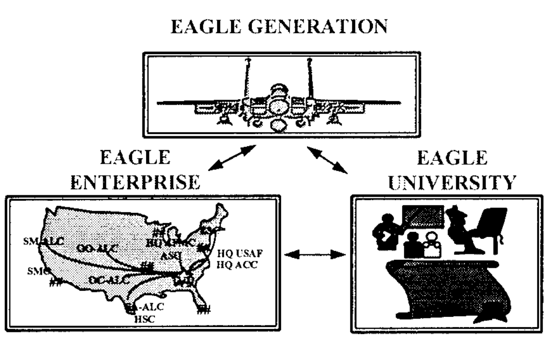
"The ***Best Fighter***...anytime, anywhere!"

From top to bottom, PMD to APB to Baselines to IPTs to vision,goal and motto, the F-15 program had made the cultural transition and others looked on to follow their lead. Teams--more so PEOPLE are the principal tool the SPD has for ensuring that the F-15 weapon system satisfies all user requirements. The bottomline is that the foundation for effective continuous improvement and reengineering is a real and demonstrated love and respect for people.



At a recent strategic offsite, Team Eagle decided to construct their future. They envisioned the jet being in the inventory until 2020. They also recognized that the Team--SPO, Contractors, MGMs/PGMs and etc., would have to do more with less resources. And that the people that would be flying, maintaining, developing and supporting the weapon system would definitely change, -many of whom are not yet born!

EAGLE FUTURE

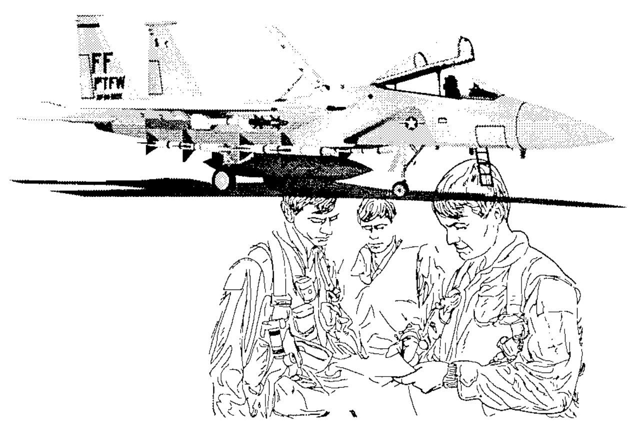


The brainchild of this thinking became ***Eagle Future***. Eagle Future is comprised of three distinct, but mutually inclusive elements: Eagle Generation, Eagle Enterprise, and Eagle University.

Eagle Generation is the roadmap we are following to ensure the F-15 will remain an effective fighter well into the 21st century. We are working hard, everyday, toward this end and our challenge is to institutionalize the process so that it becomes our everyday philosophy. Eagle Generation was a sucess story for the F-15 program--the process we employed set the stage for HQ Air Combat Command to develop the Fighter Configuration Plan (FICOP). The FICOP was used to prioritize the funding for modernization of the fighter force structure. Once again, the F-15 model of doing business--strategic planning--gets a kudo. The Eagle Generation process is being institutionalized and will continue to be used to construct the sustainment roadmap for the jet.

Eagle Enterprise is our plan to integrate and meld all F-15 people, from the users to the product centers, the ALCs, contractors, and research universities into one cohesive team. The result is "Team Eagle"--***a VIRTUAL ORGANIZATION*** whose common purpose is to make the F-15 the best fighter. To date, we have removed geography and time from the equation through our information super highway between our two SPO locations, PGM/MGMs and several key contractors. We can actually access data located at a remote location, say El Segundo CA, review and comment on bales of data right at our desk--saves shipping and travel dollars. We also keep our warfighters informed about supportability issues via our Eagle Bulletin Board or e-mail.

Eagle University (EU) is the recognition that we need a "learning organization" to keep a "core competency" within Team Eagle. EU provides Covey leadership training, Theory of Constraints, and process training. EU is also the "Keeper of the Flame"--the story, the legacy. The F-15 has quite a legacy--in the past, you would have heard aircrews say proudly "The F-15-we go where others have never gone before!"



As you can see, IWSM starts and ends with the warfighter focus--cradle-to-grave management by a single management team, TEAM EAGLE, that is accountable for all aspects of the F-15 weapon system.

GOVERNMENT PROPERTY - A CRITICAL RESOURCE IN THE ACQUISITION PROCESS

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ABSTRACT

The field of Government property has made front page headlines numerous times and has been the subject of numerous General Accounting Office (GAO) reports to Congress as well as the subject of untold Inspector General (IG) reports from all agencies, civilian and military. The field of Government property and its use in the acquisition process must be addressed for improvements to be reaped. This paper will analyze the current policy, application in the acquisition process, and changes on the horizon with the rewrite of the Government property part of the Federal Acquisition Regulation.

INTRODUCTION

"While data we obtained showed that as of September 30, 1984, contractors had over $8.4 billion of GFE [Government furnished equipment] in their possession, there are known problems concerning the accuracy of this data." [1]

"DOD furnishes billions of dollars of property to defense contractors each year. However, the exact amount of property currently in the hands of contractors is unknown." [2]

As of September 1986 there was over $45 billion of Government property reported in the possession of defense contractors. [3]

As of September 1993 there was over $90 billion of Government property reported in the possession of defense contractors. [4]

Government property has been the brunt of many jokes in the acquisition community. "Do you know what the two types of Government property are? Late and defective!" Yet, if one were to more closely analyze the impact of Government property in the acquisition process one would realize that its role is critical and, at this point in our procurement history, indispensable. In point of fact, the irrefutable claim could be made that if all Government property were immediately withdrawn from availability this action would cause the shutdown of every major weapon system acquisition. Think about it. Do any of the weapon systems you're involved with use Government property? Let's look at some of the most frequent applications.

For Aircraft - Engines as Government furnished property,
For Naval Ships - Radar, sonar systems, missile guidance systems as Government furnished property,
For Army Tanks - Treads, fire control systems as Government furnished property,
Special Tooling - to fabricate all of the above, as Government furnished property,
Special test equipment - to test all of the above, as Government furnished property,
Facilities, i.e., general purpose plant equipment and real property (Don't believe

me? Check out our GOCOs.) to produce the actual deliverable.

These are just a few examples of the use of Government property in the acquisition of DOD weapon systems. But they do serve to illustrate the critical nature of the use of Government property in defense procurement and, to some extent the overuse and over dependance upon the same. To analyze the use of Government property one must first look at the Government's policy on providing Government property to defense contractors or, for that matter, any contractor doing work for the federal government.

POLICY ON PROVIDING GOVERNMENT PROPERTY

The Federal Acquisition Regulation (FAR) is quite specific in its opening reference of, Part 45, the Government Property part. It states "Contractors are ordinarily required to furnish ALL (emphasis added) property necessary to perform government contracts." Yet, in spite of the policy we have seen the amount of Government property in the possession of DOD contractors burgeon to over $90 billion.[5] Without a doubt, there has been a dramatic increase in the amount of Government property. There may be many reasons why this has happened, increased defense budgets over the decade preceding this last report, cost avoidance through the furnishing of Government property, lack of knowledge as to the application of policy exceptions when the Government may provide Government property; the list is endless.

POLICY EXCEPTIONS

Rather than rationalize it would be better to review first the policy exceptions when Government property may be furnished to a contractor. These exceptions are not as succinctly stated or logically organized as the original policy statement. One must search and cull them out from the FAR, Department of Defense Federal Acquisition Regulation Supplement (DFARS), numerous Directives, Instructions, and Manuals, as well as civilian agency regulations. These policy exceptions, for providing Government property to contractors, consist of the following:

1. To achieve significant economy, e.g., Precious metals recovered by the Government or items from a breakout program, a jet engine.
2. Standardization, e.g., Special tooling for First Article acceptance and inspection testing or for production use.
3. To expedite production, e.g., Long lead items such as forgings or machine tools.
4. To increase competition, e.g., Special Test equipment to allow the small business to compete.
5. To support Small Business, e.g., Special tooling for the production of spares.
6. To maintain the industrial base, e.g., Industrial plant equipment to meet surge capacities at an ammunition plant.
7. Due to the scarcity of an asset, e.g., Strategic materials.
8. Lastly, the type of contract awarded, Fixed Price versus Cost reimbursement type contracts, as all property acquired by the contractor under a Cost reimbursement contract title vests in the Government.

COSTS AND RISKS ASSOCIATED WITH PROVIDING GOVERNMENT PROPERTY

Those these previously mentioned items may seem easy to understand; they are, in fact, deceptively complex. Yes, these are the policy exceptions for providing Government

property. But, those involved with the acquisition process must be aware that there are costs and risks associated with the action of providing Government property that are not elaborated upon in the policy exceptions. Let's look at some of the costs and risks associated with providing Government property.

Timely delivery and suitable for use

One of the most critical problems with providing Government property hinges upon the "guarantees" the Government makes regarding its suitability for use and timely delivery. If we allowed the contractor to acquire/fabricate all property necessary to produce the deliverable end item the contractor bears the risk of ensuring that the item does, in fact, work. When we, the Government, furnish any of the components to be incorporated into a deliverable end item the Government property Clauses stipulate that the GOVERNMENT is responsible if the item of Government furnished property (GFP) is not suitable for its intended use and the Government is also liable if the item is not delivered on a timely basis.[6] In commercial contracting you will not find an equivalent process of "providing" property to a contractor. Yet, we in the Government furnish property on a daily basis. Remember the over $90 billion out there? If that property is furnished in a condition not suitable for its intended use or in a timely fashion the Government is required to provide an equitable adjustment to the contractor. So in essence the Government has paid for the Government property originally, furnished it to a contractor, and is now paying again because it didn't work right or was delivered late. Surely there must be a better way.

Loss, Damage and Destruction

Assuming that the property got there on time and in a condition that was suitable for its intended use what could happen next? Well, if everything goes okay the end item is delivered. Sure, how often does everything go okay? Well, suppose for a moment that the contractor loses that property, or it is damaged or destroyed? Well, most Government property clauses provide for the contractor to be granted relief of responsibility if the contractor has an approved property control system.[7] If such is the case, where the contractor does not bear the risk of loss for that Government property, it is rather simple to see who is going to have to pay for the replacement of that Government property. As much as it may anger us, the Government will.

So let's see. The Government furnishes the property - its late or unsuitable for use, the Government pays the contractor to make it suitable or for any delay in production. The property breaks, or is lost, or is damaged, and the Government pays for its repair. Not a bad deal if your the contractor. A real bummer if you're the Government. I realize that I am engaging in hyperbole and speaking in the pejorative but, do you really want to furnish that property to the contractor?

Ahhhh, but there's more. Assume that everything goes okay. Property is delivered on time, its suitable for use, and there is no loss damage or destruction. That's the end of the Government's costs for this property right? Wrong. Because the contractor must also establish records, care for and maintain that property, physically inventory it and report those results to the Government. All of these actions add additional costs to the contractor's overhead, thereby increasing your procurement costs.

These are just a few example of the increased costs and risks the Government bears when it assumes the responsibility of providing Government property

CONCERNS

In 1986 former Undersecretary of Defense Richard Godwin issued a memo to all secretaries of military departments and directors of defense agencies to reduce the amount of Government property provided to defense contractors.[8]

This memo contained direction in nine areas consisting of:
Industrial facilities,
Incentives for contractor investment
Special tooling/Special Test equipment
Material
Property rollovers/transfers
Property to service contractors
Storage of Government property
Disposal/retention of Government property and
General Management areas

I would like to take a moment and discuss some of the areas found in this still applicable policy letter.

<u>Industrial facilities</u>

Put quite bluntly, the Government should not be furnishing nor should it be authorizing contractors to acquire for the Government general purpose machinery or equipment. Contractors are expected to have their own general purpose equipment for performance of the contract. Even more importantly, we expect contractors to invest their own funds in the purchase of general purpose equipment. An analogy, you contract to have your two story house painted, the painter arrives ready to go and asks, "O.k., where are the ladders?" An assumption is made that the painter has all of the necessary tools and equipment to do the job. Yes, the Government will pay for the material used in performing the contract, either through progress payments (financing) on fixed price contracts, or through reimbursement on cost reimbursement type contracts. The Government will pay for the "special" stuff, i.e., special tooling and special test equipment.[9] But it expects the responsive contractor to have all of the general purpose "stuff" necessary to perform the contract. This action, providing general purpose equipment to the contractor, does nothing but take acquisition dollars that could be spent for research, development or production of an end item and diverts them to facilitizing the contractor.

<u>Material</u>

There has been a long standing belief that material available through the Government supply system and Government inventories is stuff that's free. The Godwin memo emphasized that the Government should not be furnishing commercial, off-the-shelf material as Government furnished property. Why? Because one must again analyze all of the record keeping and usage requirements and restrictions imposed upon the contractor for the control of Government property. Contractor should be acquiring commercial, off-the-shelf material through their own purchasing system. I can hear some of you now. "But the Material Management Accounting System (MMAS allows the contractor to commingle and use material from cost reimbursement type contracts, progress payments financed material and even contractor owned material - so what's the problem?"[10] You are absolutely correct. The MMAS was developed to allow the

contractor to make maximum utilization of the inventory available regardless of ownership. With one exception - remember that commercial, off-the-shelf material you FURNISHED the contractor? Well, it is considered Government-furnished property (material) and CANNOT be included in the MMAS.

Disposal or retention of Government property

Let me take you one other area in the acquisition process - final disposal or retention of Government property at contract completion or phase out of a weapons system. Remember all that "stuff" you furnished the contractor? Well, the contract is over, the contractor doesn't want it in his/her plant anymore because some other competitor was awarded the follow-on contract. And oh, by the way, the follow-on contract awardee doesn't want the Government property because his equipment uses different processes. The Government is now responsible for disposing of those assets. Disposition can be a rather lengthy, expensive process and the monies necessary will be coming from procurement funds better spent on the product. [Note: This is even more critical if the contractor uses any type of material which may become a hazardous waste.] Lastly, in this area is the issue of retention of Government property, most notably, special tooling. For years procurement folks used the dreaded NO-COST STORAGE AGREEMENT. This item is in essence an oxymoron. There are always costs associated with storage of any type of property. In this instance there were no direct costs. Rather, the costs were loaded into overhead, thereby increasing the contractors costs across ALL contracts, Government and commercial. Yes, the logisticians are going to want to keep every item of special tooling ever created for the weapons system. There exists the pack rat mentality that we will need it one day. How many of you are collecting those National Geographics and will read them all, one day? A tough call must be made as to the probable future need of the special tooling! This call must take into consideration the cost of storing the items for X number of years, the administrative costs associated with controlling those items, the costs of shipping to another location (multiple times), the technical obsolescence of the tooling, i.e., does the equipment on which the tooling was used still exist? The real question - "Is it cheaper to store or cheaper to buy new ten years down the road?" That is a very tough question to answer.

These are just a few areas where those involved in the acquisition of weapons systems or of any item for the Government need to be aware of the impact and costs associated with the providing of Government property.

ALTERNATIVES TO PROVIDING GOVERNMENT PROPERTY

In spite of the numerous reports, the increase of Government property already in the hands of contractors there is some light at the end of the tunnel - and acquisition/procurement officials can help in this area.

Action items

STOP PROVIDING GOVERNMENT PROPERTY! Realistically, that won't happen because there are always reasons when it will make clear, good economic sense to do so. What I ask is that when you do decide to provide Government property that you ensure that it is in compliance with the specific policy directives. And, to reiterate:

• Do not authorize contractors to acquire general purpose equipment (Including computers) without the specific approval requirements set forth in the FAR.[11]

• Do not furnish commercial, off-the-shelf material from the Government supply source without an economic analysis of the cost benefit to the Government taking into consideration the previously discussed costs.

• Be prepared to promptly dispose of residual assets AND to pay for the costs incurred for the disposal of hazardous wastes.

• Understand the guarantees that the Government makes regarding Government-furnished property, i.e., suitable for intended use and timely delivery otherwise contractor is entitled to an equitable adjustment.

• Understand the liability provisions for Government property and that the Government generally acts as a self insurer.

FUTURE TRENDS

By the time you read this paper, the rewrite of the Federal Acquisition Regulations will have been underway for a period of time. The Government property section was selected by Ms. Eleanor Spector, Director of Defense Procurement, as one of the first parts to be redone. To rewrite this portion of the FAR is a difficult balancing act. Specifically it requires the application of:

Best commercial practices - What does industry do with their stuff? How do they control their assets?

Balancing cost efficiency, risk and responsiveness to the taxpayer and the taxpayer's dollar.

Compliance with law and statute governing certain Government property control situations.

In response to the numerous GAO and DODIG reports, the rewrite committee must take action to prevent the proliferation of Government property. The simplest way to accomplish this is to tighten up the policy on providing Government property. This course of action is already in the works. The policy on providing Government property will become more restrictive. The committee also acknowledges that it would be imprudent to close and lock the door entirely. There are always valid reasons, economy, expediency, standardization, etc., that call for the providing of Government property. The issue is acquisition personnel MUST be aware of that policy and make economically defendable decisions in compliance with that policy.

ENDNOTES

1 GAO/NSIAD-86-109 Government Equipment. Defense should further reduce the amount it furnishes to contractors.

2 GAO/NSIAD-88-151 Government Property. DOD's management of the property it furnishes to contractors.

3 Source: Contract Property Management System (CPMS)/DD Form 1662 as of 30 Sep Each year.

4 Source: Contract Property Management System (CPMS)/DD Form 1662 as of 30 Sep Each year.

5 Source: Contract Property Management System (CPMS)/DD Form 1662 as of 30 Sep Each year.

6 FAR 52.245-2(a) and -5(a) Both stipulate that the Government warranties that the Government-furnished property is both suitable for use and will be delivered on a timely basis.

[7] The Governemnt property clauses found at 52.245-2(Alt.I), 52.245-5(g) and 52.245-8 all stipulate that to hold a contractor liable the Government must prove willful misconduct, lack of good faith on the part of contractor's managerial personnel or have a disapproved property control system. There is extensive case law and writings on that subject including

ASBCA No. 29,831. Dynalectron Corporation, July 31, 1985.

ASBCA No. 214387. Fairchild Hiller Corporation, Nov 30, 1971.

[8] Office of Under Secretary of Defense (OUSD/A&L(PS))letter dated 25 Nov 1986.

[9] FAR 52.232-16(d) and 52.245-5(c)

[10] Department of Defense Federal Acquisition Regulation Supplement (DFARS) 242-7004 and 252.242-7004

[11] FAR 52.244-2 and 45.302.

APPLYING HARDWARE PREFERRED PARTS QUALIFICATION CONCEPTS TO THE ACQUISITION OF COMMERCIAL SOFTWARE

Theresa Ridge Huber, DSD Laboratories, Inc.

ABSTRACT

The DoD is changing how systems are developed by moving towards investing in dual use products and processes and in increasing use of commercial standards, specifications, and products [1]. Utilizing commercial products to meet DoD requirements will help reduce the acquisition cycle time, improve quality and consistency of delivered products, and as a result, reduce risks. However, to implement this new direction for acquiring commercial software products, software acquisition managers need to know not only how to obtain the appropriate products, but also how to determine if and under what circumstances the commercial products meet the DoD's requirements. To answer these questions for acquisition managers, we can start by examining the qualification process for hardware-related parts, which can easily be applied to software products.

This paper details how qualification concepts for hardware preferred parts can be applied to the acquisition of commercial software products, by examining the concepts and vision of establishing a centralized organization to acquire, qualify and distribute commercial software products for systems in similar application areas. This vision and associated concepts described in this paper were developed jointly by the Air Force's Comprehensive Approach to Reusable Defense Software (CARDS) [Contract #F19628-93-C-0130] and NASA's Software Optimization and Reuse Technology (SORT) - Reuse Adoption and Techniques Team (SRATT) [Contract # WVHTC-F-S94-1008] Programs, with support from the the Air Force's Portable, Reusable, Integrated Software Modules (PRISM) Program.

INTRODUCTION

There are various software-related concerns in the DoD: software systems take too long to develop (costs and schedules are underestimated); costs of software development are increasing, and at the same time the quality of initially delivered software is not sufficiently high [2]. To address some of these concerns, the Secretary of Defense has issued a directive [1] to move towards the use of industry specifications and standards. The goal of this mandate is to streamline and simplify the way DoD purchases systems by removing military-unique specifications, providing access to state-of-the-art commercial technology, and developing non-Government standards in partnership with industry. This ruling provides a preference for commercial items for Government-unique requirements and removes impediments to using commercial products. In fact, utilizing commercial software in system development can result in significant benefits. However, several concerns have been raised from the Program Management and acquisition perspectives: where are components found?; how are components determined suitable for a particular application?; and how does one address the increased schedule and expense of conducting preliminary analyses?

To address these concerns, a central organization(s) could be designated to conduct preliminary analyses to determine

needs of similar systems, acquire the needed commercial software products, examine the products for suitability for systems within an application area, and distribute those products to Program Offices and system developers. One solution is to apply hardware preferred parts concepts and current software reuse practices [3] to the purchase, qualification and distribution of commercial software products.

For hardware parts, qualification is performed in advance of need and independently of any specific acquisition. The names of successful products, manufacturers or potential offerors are included on lists showing their status. There can be several sets of criteria for which the part is evaluated against. For example, the evaluations can be based on a Program Office's criteria for a particular application or they can be based on industry standards/specifications.

The process of qualifying hardware parts based on certain specifications and standards, and then using those pre-qualified parts during development, can easily be adapted to software [4]. The policies and procedures in the Federal Acquisition Regulation (FAR) Part 9.2, which govern the qualification of hardware-related parts, is valid and applicable to such a concept for software components [4].

The remainder of this paper details the vision and associated concepts to establish a non-profit organization to centrally acquire, qualify and distribute commercial software products for systems in a similar application area (e.g., command centers) or product line (e.g., PRISM - a specific architectural approach for command centers). This approach will establish a central source for Program Offices and system developers to obtain commercial software products and information on the use of those products within the particular application area. A consistent verifiable approach to qualifying components will be provided to the customers of this centralized facility [2].

This centralized qualification facility will be a source of proven, reliable components for incorporation into architectures for common systems and will accelerate the development or modification of those systems. This effort supports DoD policy changes to use commercial products and components by not only making those software products available, but by conducting analyses that are required prior to requirements analysis. This concept helps meet the DoD's goals of increasing use of commercial products and standards, which will allow for more effective and efficient evaluation and maintenance of "existing" components.

COTS SOFTWARE QUALIFICATION CONCEPT OF OPERATIONS

To reiterate from above, the central organization will acquire the needed commercial-off-the-shelf (COTS) software products, qualify the products for suitability for common applications, and distribute those products for use by Program Offices and system developers who develop systems for the particular application area (e.g., command centers). Figure 1, Component Qualification Process, represents the overall process [2]. A commercial product is acquired (or submitted) for qualification, the product is qualified, placed on a list, and through the use of various delivery mechanisms is made available to Program Offices and system developers. There would be a different set of qualification criteria for each application area or product line.

The major participants in the process are the

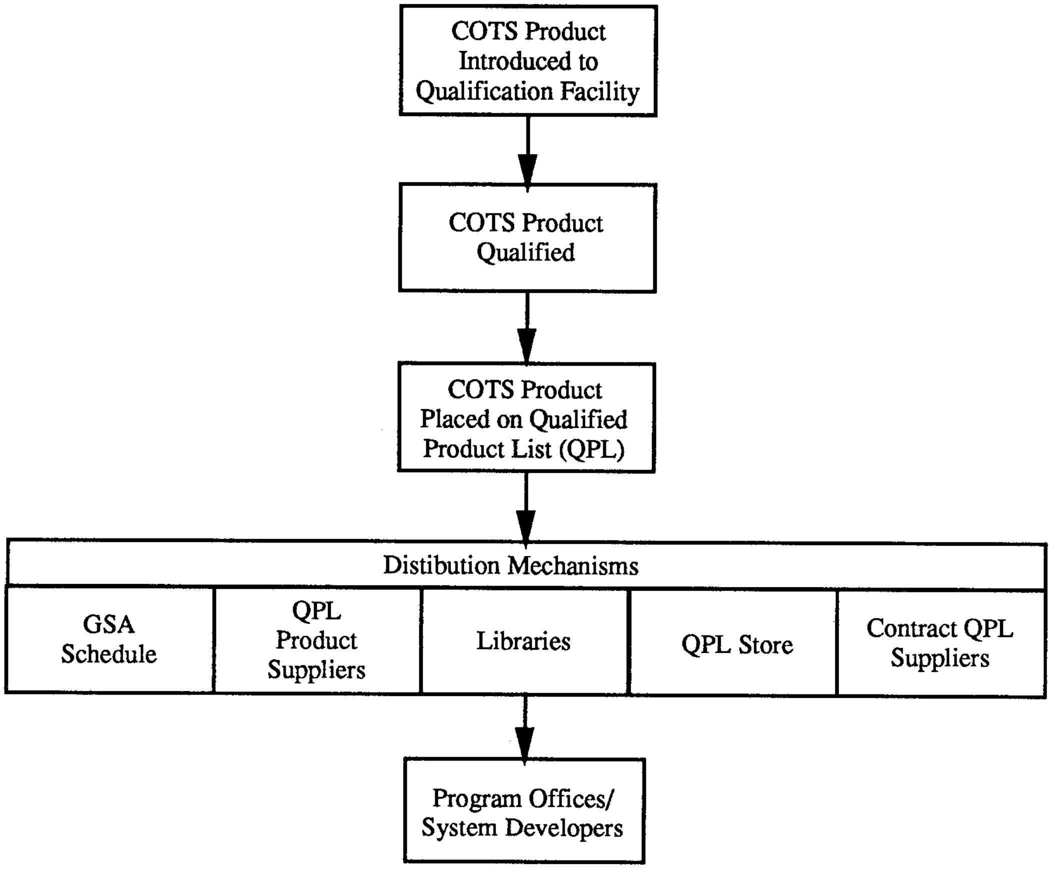

Figure 1: Qualification Process

Acquisition Organization, Commercial Software Vendors, and the COTS Qualification Facility, which are illustrated in Figure 2.

As Figure 2 shows, the acquisition-related responsibilities is separated into 3 groups: users, Program Offices/System Developers, and Product Line Organization [3].

The user's role here is the same as the traditional role of stating a need and generating requirements. The Product Line Organization manages the use and reuse of software across systems within a particular application area. Included in this role is the product line engineering team which conducts the preliminary analyses and develops the generic requirements for the group of systems. Based on the analysis, the product line engineering team develops and maintains the software architecture and the evaluation criteria that will be used by the COTS Qualification Facility to evaluate products for use by system developers. The Program Offices and System Developers utilize the information supplied by the Product Line Organization to assist them developing systems based on common architectures and commercial products.

The commercial software vendors provide

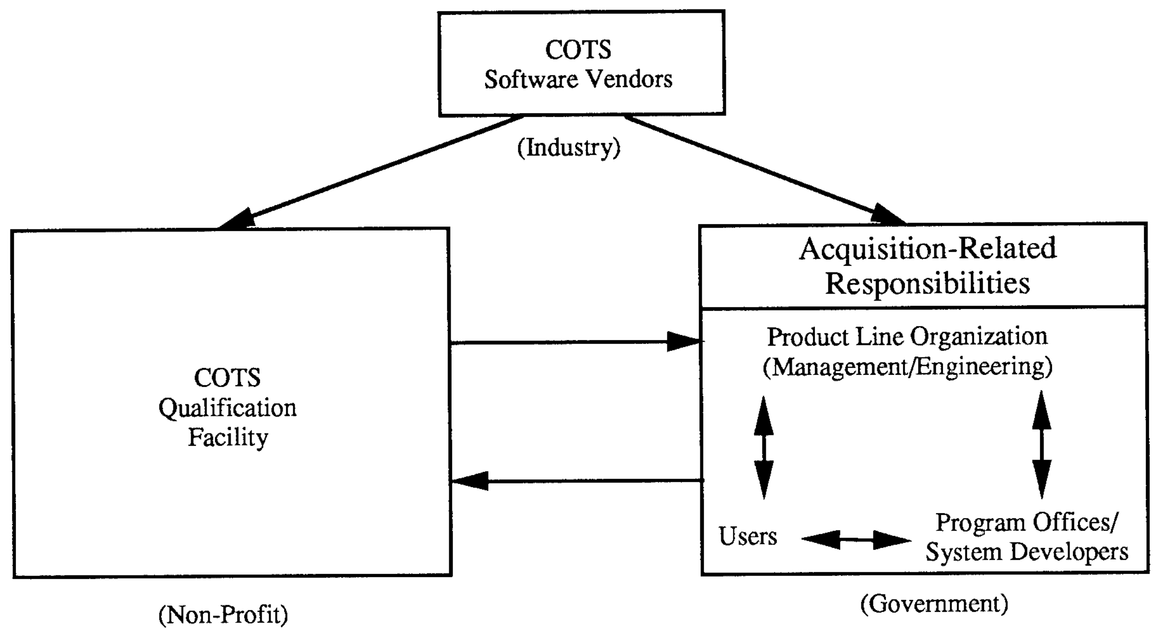

Figure 2: Major Roles

their products to the facility for qualification. The current plan is to follow the hardware model, where the vendor would pay for the qualification, unless they are an 8(a) company. The vendors obtain the qualification results from the COTS Component Qualification Facility to guide revisions and updates of products. These results are also provided to customers when distributing the products through their own distribution channels.

For this concept to be successful, the COTS Qualification Facility will be operated under federal sponsorship by an independent, non-profit organization. The facility must demonstrate no conflicts of interest. They must not be in the business of developing systems in the chosen application areas and will be prohibited from competing for work in which the qualified products are used. The facility will also be required to show a capability to safeguard sensitive vendor information.

As illustrated in Figure 3, the COTS Qualification Facility has 4 major roles: management of the process, acquiring the products, qualifying those products, then distributing them to appropriate users. The management role covers both the internal management of the entire process and interactions the organization has with industry as a whole. The acquisition role pertains to the qualification facility's interaction with COTS vendors. The qualification role pertains to the qualification facility's interaction with the Product Line Engineering Team. The distribution role pertains to the qualification facility's interaction with Program Offices/System Developers. These roles are described below.

COTS QUALIFICATION FACILITY

To establish a successful organization and a market for the qualification and distribution of COTS products, the COTS Qualification

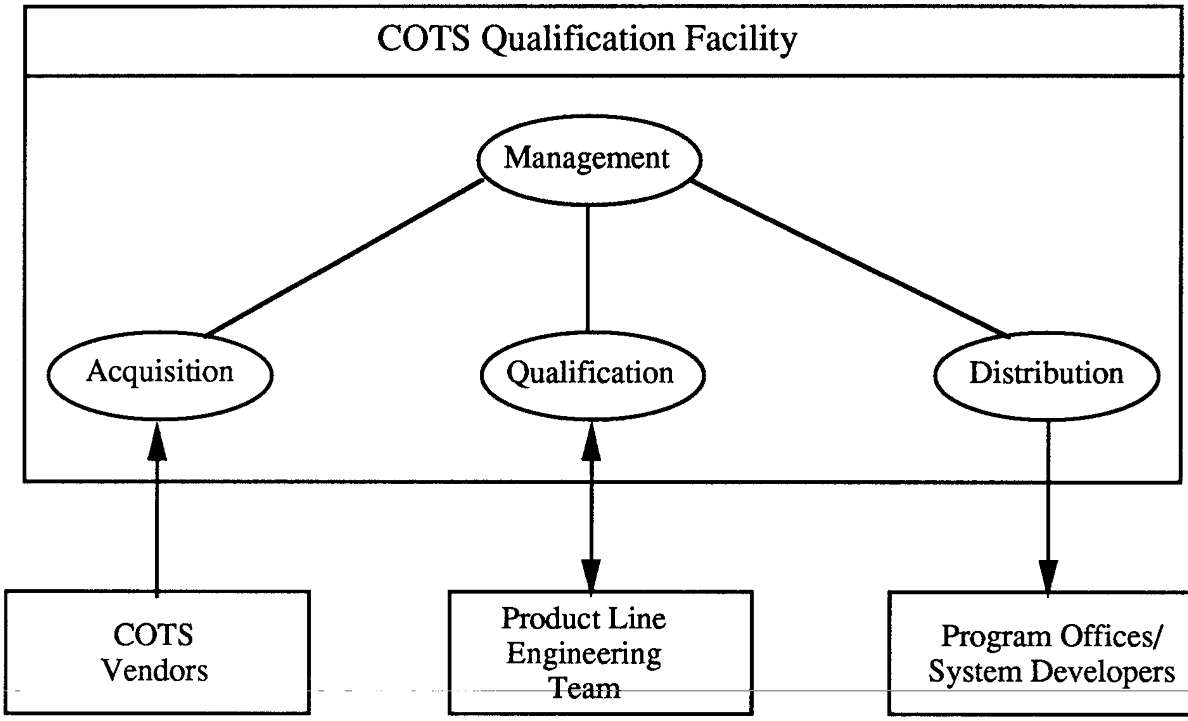

Figure 3: COTS Qualification Facility: Roles and Interactions

Facility must interact and collaborate with all the major players, as well as Government, industry and academic interest groups, to get feedback and participation. The widest possible participation is needed up-front in the development of the qualification criteria and the product qualification and distribution processes to ensure agreement and buy in by stakeholders in the market. COTS Vendors would be interested in reviewing and commenting on the submittal, qualification and distribution processes. They would primarily be interested in safeguarding sensitive or proprietary data. Since Program Offices and System Developers will rely on the suitability and acceptability of the products for use, they would be interested in reviewing and commenting on the qualification process and distribution processes. The COTS Qualification Facility will need to establish relationships with the various chosen product line organizations to establish the process of providing feedback on qualification results.

Advertisements and announcements of the creation of the COTS Qualification Facility and the general concepts behind it, will be disseminated utilizing various marketing efforts: brochures, conference presentations, internet discovery tools, such as Mosaic Home Page, Government electronic bulletin board systems, and the Commerce Business Daily (CBD).

Various stakeholders will be solicited to review and provide comments on the different processes mentioned above. First, announcements will be made explaining the concept of operations of the facility. Then, the background material will be

disseminated for use in two workshops to be held to draft the operational processes (one for technical and one for business). The workshop results will be draft qualification criteria and business arrangements for the facility to use as a baseline.

In the short term, the Government will expense initial capital and operating costs through an agreement which supports the establishment and operation of the facility. In the long term, the COTS Qualification Facility will become self-sustaining. The facility will charge vendors fees for qualifying products and will charge the users of products a small fee for distribution of products and the qualification results. The fees will cover the recurring costs of the process, but will be reasonable enough to encourage vendors to submit COTS products for qualification.

Some type of policy is needed so that system developers are either encouraged or required to utilize qualified COTS products. To ensure a market for components, it is assumed that the Government will eliminate contractually required testing of that component. An alternative is to require system developers to demonstrate why a particular product can not be used. Any request should address requirements, risk, cost and schedule. This will in-turn ensure that there is a market for the products and encourage vendors to submit their products. Thus, the Government needs to provide a clear perception to vendors so that their ROI predictions will justify their participation and will increase the acceptance and use of their products in the marketplace [2].

In interacting with COTS vendors, the COTS Qualification Facility must establish a means to solicit vendors to submit products and develop formal agreements to describe the business relationships.

COTS vendors will be solicited by various avenues. These include: soliciting Requests for Information using the Commerce Business Daily, making requests directly to vendors, establishing and conducting working groups with vendors, and by using currently established Government electronic bulletin boards.

Formal agreements will need to be established with the various vendors to document the terms and conditions of the business relationships. Agreements will cover product submittal process issues, such as feedback on results of the qualification, an appeal process, if the vendor does not agree with the qualification results, how product upgrades/enhancements will be treated, and protection of proprietary data. Other terms and conditions of the agreements will cover how to distribute products to end-users and the qualification policies/procedures.

It is extremely important to choose an application area that has a strong foundation of commercial products (i.e., a market already exists), so that it will be cost effective to establish the infrastructure and support processes.

The first application area will be command centers and the first product line will be the Air Force's generic architecture from the Portable, Reusable, Integrated Software Modules (PRISM) Program. The command center application area has functional areas common to the Management Information Systems (MIS) application area and has a large base of COTS products (e.g., Database Management Systems, Network Managers, Geographic Information System, and Message Translator/Validator). In addition, command centers is one area in the DoD that are continually being upgraded to reflect new technologies.

A set of qualification criteria will be developed for product lines within an application area (e.g., the PRISM generic architecture for command centers). The set of qualification criteria will apply generally to the product and for each function within the application area (e.g., geographic information system, message translator/validator). If one product fits into two different application areas, then it would be evaluated twice, using the two sets of qualification criteria. If the product fits into two different functional areas within a product line, then it is also evaluated twice, once for each function.

Products will be qualified against product line requirements and architecture constraints, both on a stand alone basis, and through integrating the product into a prototype.

The COTS Qualification Facility must work closely with the Product Line Engineering Team to ensure that continual feedback is provided on the results of qualifications, so that the architecture and associated qualification criteria are properly maintained.

Once the COTS products are qualified, the results will be disseminated to all parties involved: the COTS vendor, the Product Line Engineering Team, and the Program Offices/System Developers. The information to be disseminated will include a description of the product, the stand alone qualification results, and the analytical results of how the product integrates with the other products in the architecture. The COTS vendor would use the information for future enhancements of the product, as well to include with the product for any future direct sales. Program Offices/System Developers not only need access to qualification results, but also need a capability to purchase the commercial products. The COTS Qualification facility will provide mechanisms for Government agencies and their contractors to purchase these qualified COTS products.

There are many possible channels and mechanisms to use for distributing COTS products and qualification results that may be feasible to use (See Figure 1). Products may be available thorough the GSA, directly from COTS vendors, identified and accessible through reuse libraries (e.g., Asset Source for Engineering Technology, (ASSET), CARDS Command Center Library, Defense Software Repository System (DSRS), and the Army Reuse Center), or a contract that contains these components (e.g., an 8(a) or other suitable mechanism). Products could even be obtained directly from the qualification center if it could be done without the appearance of conflict of interest (i.e., the qualifier is not compromised by also being a non-exclusive source of qualified components [2]).

CONCLUSIONS

This concept of a centralized facility to acquire, qualify and distribute commercial products to Program Offices and system developers is valid, needed and valuable to meeting the DoD's directive to increase the use of commercial software. To summarize, the facility will collect results of preliminary analyses from participating product line engineers to determine the need for certain commercial products. Based on analyses performed by product line engineers, the facility will acquire the needed commercial software products and examine them for applicability to systems within an application area. The facility will also distribute those products, and associated qualification results, to Program Offices and system

developers.

There are two major challenges confronting this effort. The first challenge is establishing a market for qualified component. This challenge is to establish a demand by the customers (acquisition managers and system developers) for the commercial software products. Having a customer base will provide an economic incentive to vendors to submit their products for qualification [2]. The second challenge is the capability of applying commercial software products in Government system development efforts [5]. This brings up many sub-issues, such as how the software will be maintained, determining the suitability of COTS software for use in mission-critical systems, and obtaining support (documentation & maintenance) by vendors for the life of the system [6].

Given that these challenges can be met, there are several benefits to this strategy. By utilizing pre-qualified, existing products and the results of the product line analyses, the development cycle time can be reduced and the quality and reliability of systems can be improved. Further, training and maintenance costs can be reduced because of enhanced familiarity with and improved reliability of reused components [1]. This strategy also improves quality and consistency of delivered products, as well as establishing core competencies around strategic business interests.

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STATISTICS, TOTAL QUALITY MANAGEMENT (TQM) AND ACQUISITION STREAMLINING

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ABSTRACT

Statistics can be used in a variety of ways. An integral element of Total Quality Management (TQM) is the need to verify "facts versus opinions" using metrics to isolate/minimize emotionalism. Statistics can also be used to explain what might be considered an "irrational" stance on an issue. Statistics definitely have a role in attempting to quantify risk.

This paper develops a paradigm to analyze risk using simple statistical tools. This paradigm can be applied to decisions within acquisition circles where the consequences of making a mistake may be relatively small or where a mistake may mean life or death.

INTRODUCTION

Years ago, when I was a practicing aircraft maintenance officer, I tried to figure out why technical inspectors (TIs) seemed "irrational". Right behind the 1st rule of "Light's Laws to Aircraft Maintenance" (If it ain't broke, don't fix it) was "Don't rationalize with irrational people--TIs." It seemed their orientation on decisionmaking was different for, at times, it seemed they would pull perfectly good parts out of a helicopter and replace them. I later was given some statistical tools at school that revealed they were not only rational, but quite conscious of the consequences of their decisions.

BODY/TEXT

While attending graduate courses at the Naval Postgraduate School in Monterey, CA, I received a course on statistics. Normal curves (Bell curves) were included routinely in analyzing all sorts of problems. One would set up a hypothesis and then go about setting a "confidence factor" to prove or disprove the hypothesis. "Alpha" represented a probability and is shown in Figure 1 as a "tail" probability. When calculating whether the hypothesis was rejected, the point of rejection occurred when the calculation placed you in the "tail" area {The probability of rejecting an otherwise true statement}.

Now back to TI s. Let's statistically examine why he decides things as he/she does. Say he assumes a part or work completed is "O.K." and in reality, it is. He's right and he signs off the fault in the logbook. Suppose he assumes the part/work is "bad" and it is--again, he's right and properly rejects the work and directs that it be redone.

Suppose now he assumes a part or work completed is "bad", but in reality, it was just fine. He has committed a Type Alpha error and rejected the initial or "null" hypothesis. The consequences of his error are wasted time, money, and effort. Risk in this area is generally considered low. But take a look at a more costly error... suppose he/she accepts parts or work completed as "O.K." that are indeed defective. He has now committed a Type Beta error and erroneously signed-off the fault. The consequences of this error, carried to the extreme, are damaged equipment or loss of life.

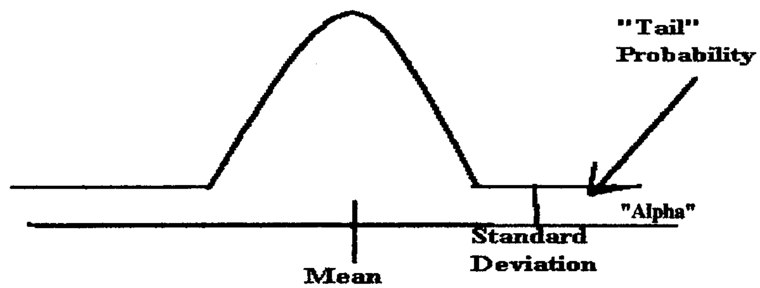

FIGURE 1

ASSUMPTION / REALITY	Part/Work is "O.K."	Part/Work is "Bad"
Part/Work is "O.K."	**CORRECT: "Insp O.K."**	**Type Alpha error: Wasted $, time, effort {LOW RISK}**
Part/Work is "Bad"	**Type Beta error: Potential damage to property or loss of life {HIGH RISK}**	**CORRECT: Reject repair & direct work to be redone**

FIGURE 2

So, I concluded that TIs rationally determined that the error with the worst consequences were the ones to be avoided (Type Beta errors). Therefore, if a TI had

any doubts, he would default to the lower risk error of rejecting the part/work erroneously vs. accepting faulty work and perhaps hurting someone.

As Total Quality Management (TQM) made its debut in acquisition circles, it focused primarily on three principles--Employee Involvement, Continuous Process Improvement vs. Product Orientation, and Metrics to separate "opinions" from "facts". Simple tools revolved around normal "bell" curves and reducing process variability around a mean. As TQM evolved, statistics started being used in acquisition circles to prove or disprove assumptions. Today, we find Requests for Proposals (RFPs) statistically analyzed to determine whether or not they adhere to acquisition streamlining principles. Well, let's apply the Type Alpha/Beta analysis to acquisition streamlining for a moment.

Assume for a moment that as a general rule, the acquisition community will now accept the general proposition that contractors are "Responsible and trustworthy." By virtue of this assumption, acquisition streamlining seems to make a world of sense. Why impose unnecessary regulations and "how-tos" on a contractor who would have done the "right" thing anyway. Figure 3 illustrates a complementary argument to the one of the TI s.

ASSUMPTION / **REALITY**	**Contractors are Responsible and Trustworthy**	**Contractors are not Responsible and Trustworthy**
Contractors are Responsible and Trustworthy	**CORRECT: Acquisition streamlining works, saving $, time, and effort**	**Type Alpha error: Government wastes $ on unneeded MILSPECS, MILSTDs and "how-tos" in contracts**
Contractors are not Responsible and Trustworthy	**Type Beta error: Government discovers the consequences of this error in equipment that doesn't work or, at the extreme, people who die in combat or training**	**CORRECT: Based on past performance, Government appropriately levies MILSPECS, MILSTDs, and "how-tos"**

FIGURE 3

Again, the consequences of one's assumptions are most damaging with the Type Beta error, perhaps explaining why some are reluctant to totally embrace some aspects of acquisition streamlining as it is presented today.

CONCLUSIONS/SUMMARY

The pendulum has swung over the years from overly restrictive regulation ($600 toilet seats) to minimal regulation based on a "best value" approach. We, as a community, should not have to wait for a catastrophe to occur before reaching the epoch of the

extremes and causing the pendulum to swing back toward the center. Project and product managers (PMs) must also be allowed to analyze and comment dispassionately on current policy without being accused of "old style" thinking. Granted, one must sometimes turn 90 degrees to get out of a rut, but if that rut is adjacent to a cliff, you may want to insure you turn on the correct side of that rut.

Acquisition corps officers and civilians can make life and death decisions, just like combat commanders. The difference is they are insulated from the immediate effect of their decisions because some decisions do not take hold until years later. A second difference is the soldier has to live with many decisions for the rest of the weapons' systems life cycle. The examples cited above are simply food for thought in the progressive evolution of new and innovative acquisition strategies for the future.

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A VISION FOR ACQUISITION IMPROVEMENT- THE AIR FORCE MATERIAL COMMAND (AFMC) COUNTRY STORE

By

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THE PROBLEM

Information systems technology development is increasing at a faster rate than anyone ever could have anticipated. The new product introduction cycle for personal computers is less than a year. This is not to say that these products are unusable in a year, but increased capabilities and features are constantly being offered. The benefits of these new products draw customers and diminish the interest in existing hardware and software. Hardware continues to get smaller with increased performance, memory, storage, and speed. Software applications offer more features, ease of operation, compatibility, security, and integration. However, newer software applications may not be backward compatible with existing systems. Video teleconferencing (VTC) systems are also constantly increasing their products and features in a similar product introduction cycle. However, the video conferencing industry has not yet established a universal standard which would make all VTC systems interoperable. Networks and communications carriers are also increasing performance and offering new services and packages at a rapid rate. So many services are offered that it would be impractical for an individual user to maintain currency with the offerings. With current technology, an "office" is no longer restricted to the traditional location. The "office" now includes the home, a hotel room, the car, the airport or anyplace else where a modem connection is available.

Because of the pace of technology, the usual acquisition lead time for systems involving commercial products has become unacceptable. In most cases, the larger acquisitions have taken up to two years to get to contract award. For a new requirement involving any sort of technology, the traditional system development life cycle would only be feasible if it were possible to "freeze" requirements and technology for about two years. By the time large computer contracts are awarded, systems offered are a year behind current commercial offerings. Also, prices which may have seemed attractive at the start of the process are not a good deal shortly after award. Even worse, because these models may have been "closed-out" by private supply sources the now obsolete system is very difficult for the customer to sustain.

Organizations have not been building information systems using a well-planned top-down design. Acquisition program offices have been purchasing "exactly what the program office needs." Each solution may not be in line with their neighbor, creating "islands" of automation. Because a typical program office deals only with a limited set of offices (3-4) on a regular basis, their choice of systems reflects a small slice

of the command. When individual systems were put in place, many offices had no idea what standards were being pursued, whether their efforts duplicated another office's efforts, or if the solution had already been developed. The buying of systems in isolation, largely by individual program offices results in a "bottom-up" design of the command's information system, with the interfaces between offices mostly ignored.

To compound the resulting interoperability problem, the present command structure is the result of a merger of several separate commands with differing information systems structures and systems with only limited compatibility.

The existing contracting process itself is also a barrier. Large contracts demand lots of lead time, even though requirements and technology change. Acquisition panels are followed by numerous meetings until finally all the paragraphs of the solicitation are in the right order. The acquisition team spends much of their time changing the wording to reflect the current reviewer's comments. This process seems to have changed every time a new acquisition is initiated. The result is that the acquisition team gets so bogged down with contracting matters, they lose sight of the user's needs, and have difficulty maintaining currency with the commercial market.

FINDING A MODEL FOR THE SOLUTION

Because the acquisition system has become so complex and time-consuming, it defies a solution without a radically new approach to re-engineer the entire process. The solution however is not to develop a more complex system, but a relatively simple system.

A hundred years ago, the country store was the source of supply for many people. But the old-time country store was more than a place to buy things. It also was a source of product information which many people relied upon to arrive at their decision. The country store also provided a referral service to direct customers to other more appropriate sources of supply. When a customer's unique need could not be satisfied any other way, the country store would obtain the item for the customers. A bulletin board allowed the customers to post their own items. The country store had constant feedback from its customers and could act accordingly. The country store was not a mandatory source of supply, since it had to be good enough to bring back satisfied customers. Being a central resource, there was strength in numbers and a vision in serving the entire community.

Even today, the small New England hardware store still serves a similar function in providing the "value-added" product information which one needs to select the right materials for a home repair project. Admittedly the small hardware store is a dying breed in trying to compete pricewise with the giant "home warehouses". But although the "warehouse" store has slightly lower prices and more selection, they may not provide product advice. Without product information, you would often buy a product which is not suitable for your home repair job, and ends up being returned to the store. My local New England-style hardware store can tell me exactly what I need to do a job, and often how to do it. The storekeeper can even tell me if one of my neighbors did a similar project. The store gets feedback if I'm not successful, and something has to be custom made. Project success is less risky when I deal with my

local hardware store with their value-added customer service. In a similar way, Air Force program managers are too busy building state-of-the-art airplanes to acquire the information technology product knowledge necessary.

THE SOLUTION

Just as the old-time country store served its community, the AFMC Country Store is a source of product information, contract sources, and resources to help end-users to clarify their needs, acquire the right products, or find a solution already developed and available. The Country Store takes the concept a step further in applying principles of Total Quality Management, including strategic planning, organizational improvement, employee empowerment and teamwork, primary attention on customer needs, and feedback and measurement of performance. As an improvement of the old-time country store, the AFMC Country Store's information is available on-line and readily accessible at any time. Many requirements can be satisfied by locating an existing contract, or finding a software tool already developed. The Country Store provides listings of resources to further help the customer, including listings of expert help, guidebooks, directories and other items. The Country Store offers guidance on current standards and the state of technology for those products. The Country Store's leadership in system interoperability and standards can foster increased connectivity which will gradually eliminate automation "islands".

How does the Country Store improve acquisition? First of all, fewer acquisitions will be necessary as the Country Store helps people find ready sources for their information technology requirements. This alone is an advantage, since the acquisition cycle has been immediately shortened. With fewer acquisitions, resources can be tasked to accomplish the remaining acquisitions with better focus on total quality and command-wide objectives. Second, the central listing of contracts will allow users to compare offerings much easier than previously to obtain exactly what they need at the best price. Through the Defense Information Systems Agency (DISA), arrangements are being made to be able to scan available contracts across all services and civil agencies. Third, the Country Store provides software process tools approved by the process owner in several functional areas of acquisition. Facilitating the use of approved tools can foster the use approved best practices. Also, the Country Store is set up to anticipate requirements through periodic surveys, and its ties to the local bases. On-line feedback can be incorporated into acquisition action much more efficiently than previously unstructured methods. The Country Store has packaged complete solutions to problems in plain language, describing the technology and where it can be obtained. The Country Store has offered such "packaged solutions" on video conferencing systems, groupware, e-mail systems, Internet software, and security tools. Through better knowledge of requirements with closer proximity to the actual need, the Country Store can initiate or arrange acquisition of products which meet the user requirements and command objectives. Finally, there is economies of scale in having the volume generated by a central repository. Opportunities for smaller "best-value" or cost-based acquisitions can be easily identified and accomplished through the Country Store structure, with a quicker "turn-around" from initial need to final satisfaction.

How is the Country Store structured? The Country Store is a "virtual" store made up of a "wholesale" operation which operates the information system and performs central support to field "retail" stores at each Country Store base. Each AFMC location and the Pentagon has a "retail" Country Store operated by the Base's Communications Group. As requirements are identified and validated, the retail Country Stores use the information system to review the existing contracts, and the listings of software tools available, to ensure that a duplicate effort is not undertaken.

How does the Country Store provide information? The Country Store's information system is designed to provide access to all levels of computer capability and expertise. In its simplest form, the Country Store provides automatic reply by e-mail of any or all of the Country Store documents. By sending a message to the Country Store, a general catalog is provided which is an index of all of the Country Store documents and resources. To receive a document, an e-mail listing the document name in the message field provides the document. The same documents are available on-line by accessing the AFMC Bulletin Board, available in several forms. Users can also access the Country Store directly using Gopher. The latest implementation of the Country Store is via the World Wide Web. The Country Store has its own "home page" which can be accessed using a Web "browser" such as Netscape or Mosaic. Under the Web implementation, the Country Store has been able to link directly (via hyperlink) to the actual files and information located on the Web, without having to duplicate the information. The Web constitutes the future of the Country Store as users gradually acquire capability to access by this method.

The Country Store story is only beginning. The opportunities are tremendous to achieve a number of objectives. For example, electronic commerce is being looked at in depth, as a way of achieving even greater benefits. As the use of the Country Store grows, even with the present structure, benefits will appear.

In summary, the AFMC Country Store provides a structure and centralized information to accomplish a number of command-wide objectives, including implementation of best practices, increased compatibility of systems through standards and technology improvements, closer attention to customer needs and faster acquisition, eliminating unnecessary acquisitions, cost reduction, achieving higher productivity with less people, and ultimately resulting in a re-engineering of command efforts to better support our mission.

ACHIEVING INTEGRATED LIFE-CYCLE DEFENSE TECHNOLOGY and SYSTEMS MANAGEMENT

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ABSTRACT

The present world and national environment requires substantial changes in the defense systems acquisition planning and management process including: (1) expansion of its purview to cover the life cycle of defense systems, not only acquisition, and (2) integration of Defense Technology Management (DTM) with life-cycle Defense Systems Management (DSM). To support this thesis, we discuss a life-cycle concept of DSM, and implications of the new Defense Science and Technology Strategy for DTM. We propose "informational" integration of DTM with DSM over three stages of a defense system's life cycle to achieve <u>integrated</u> life-cycle Defense Technology and Systems Management (DT&SM). Then we describe applications of new Information Management Technologies (IMT) that will enable achieving "informationally" <u>integrated</u> DT&SM throughout defense system life cycles.

To advance toward this goal, we propose four initiatives by the Under Secretary of Defense for Acquisition and Technology (USD(A&T)) to begin development of IMT-aided tools that will support achievement of <u>integrated</u> DT&SM. These tools will enable any DT&SM professional: (1) to locate and ascertain the DTM or DSM subject areas of every available major organized collection of DT&SM knowledge and information (K&I) distributed throughout the DT&SM community, and ultimately (2) to access a chosen collection and retrieve specific K&I relevant to the professional's task at hand. They would also help Air Force's Integrated Weapon System Management (IWSM) develop a truly common IWSM language.

INTRODUCTION

The post-Soviet world environment; the prospect of limited defense budgets throughout the foreseeable future, and the new Defense Science and Technology Strategy, combine to require substantial changes in the Defense Systems Acquisition Management (DSAM) process. First, they require expansion of its purview to cover every stage of a defense system's life cycle (i.e., expansion to a life-cycle DSM process). Secondly, the new DoD strategy for Defense Science and Technology Management (shortened in this paper to Defense Technology Management or DTM), will require the integration of DTM with DSM throughout the life cycle of every defense system. This cannot be achieved through organizational integration. Fortunately, recent advances in Information Management Technologies (IMT) now enable "informational" integration of DTM and life-cycle DSM, to achieve <u>integrated</u> Defense Technology and Systems Management (DT&SM) throughout each defense system's life cycle.

To support this thesis, this paper builds upon concepts first outlined in our research papers for previous Acquisition Research Symposia (ARS): 1991, "Achieving Excellence in Management of Defense Systems" [1] and 1993, "Acquisition Knowledge & Information Locator System." [2] The paper also considers important new developments in the defense systems management (DSM) environment, and in information management technologies (IMT), to update and extend our earlier concepts for providing every DSM professional more timely access to relevant DSM knowledge and information (K&I) for systems management tasks at hand.

One new development concerns a kind of K&I that DSM professionals must now consider throughout the system's life cycle. Deputy Secretary of Defense John Deutch announced this Administration's new Defense Science and Technology Program on 5 October 1994, and two new implementing documents, *Defense Science and Technology Strategy* and *Defense Technology Plan.*[3] Thus, Defense Science and Technology

Management became a new integral part of the three-stage (acquisition, operational employment support, and final disposition) life-cycle management process that we named Defense Systems Management (DSM) in our 1991 ARS paper.

The new integrated whole body of DTM and DSM knowledge will be represented in this paper by the acronym DT&SM (Defense Technology & Systems Management). This integrated DT&SM knowledge is needed to continually manage the conception, development and application of affordable leading technology throughout the life cycle of all defense systems. Given austere defense budgets for the foreseeable future, integrated DT&SM knowledge is required to best assure continued technological superiority of our defense systems, and their sustained operational suitability and effectiveness in all stages of their life cycles.

The concepts represented by the acronyms DSM, DTM and DT&SM are central to improving life cycle management of Defense systems. Each will be discussed in turn. These acronyms are identified here so we can, at the beginning, state our purpose more precisely and provide an overall framework which will enable better understanding of these concepts, their importance, and their interrelationships when they are discussed.

Our primary purpose is to propose early development of two defense systems management tools. These and two subsequent tools will enable increasingly integrated, less costly, and more effective management of defense systems to assure their continued operational effectiveness over their life cycles. Together, these tools will provide:

a. To any DT&SM professional, working on any aspect of a defense system's life cycle,

b. Timely access to specific relevant DT&SM knowledge and information (K&I) that is available in any K&I SOURCE, [4]

c. When needed by the professional for a DTM or DSM task at hand.

Proposed Initiatives. To achieve integrated management of defense technology and systems over every system's life cycle, we propose the following initiatives by the Under Secretary of Defense for Acquisition and Technology (USD(A&T)):

1. Initiate immediate development of an on-line[5] **DoD Macro-level DT&SM Thesaurus Structure** (of the terms representing key DT&SM concepts, and the equivalence, hierarchical and associative relationships among the terms) that will enable ultimate development of a two-level **DoD Thesaurus of the Body of DT&SM Knowledge**.

2. Then, as first application of this DoD macro-level thesaurus structure of key DT&SM terms, initiate development of an on-line **DoD Macro-level DT&SM Knowledge Locator System** (based on a DoD Thesaurus of Available SOURCEs of DT&SM K&I), which any DT&SM professional can use to quickly **locate available** major **SOURCEs** of **DT&SM K&I**, distributed throughout the DT&SM community.

With this Locator System alone, any DT&SM professional with a DTM or DSM task at hand, can quickly scan all available SOURCEs throughout the DT&SM community, and locate and select those with collections most likely to have DTM/DSM K&I that are pertinent to the immediate task. Then, the professional can use the particular micro-level access system, provided by each selected SOURCE to access its collection of DTM/DSM K&I, to retrieve specific K&I that are relevant to the professional's task at hand.

After the Locator System is under development, two other applications of the basic thesaurus structure tool above, will assist further integration of DT&SM. The first, prompted by the next initiative, will enable yet more direct, timely, selective access to specific relevant knowledge. The second, prompted by the last initiative, will promote a common DT&SM language for communicating and coordinating effectively in life-cycle management of defense systems.

3. Encourage **evolutionary extension** of the on-line DoD macro-level DT&SM Thesaurus Structure down into **every** major

SOURCE of DT&SM K&I that has been included in the DoD DT&SM Knowledge Locator System.

Each evolutionary extension down should, with USD(A&T) coordination and support, be developed by each respective SOURCE. The same IMT and thesaurus construction aids are available to all. However, each organized SOURCE has the best working knowledge of its own particular DT&SM subject matter, and which terms would be most useful for its micro-level thesaurus structure. So, **each SOURCE** should develop its own on-line **micro-level thesaurus of the special DT&SM K&I** (e.g., documents, data, expert consultation) that are **available in the SOURCE.**

An example of a major SOURCE is the Manpower and Training Research Information System (MATRIS) Office of the Defense Technology Information Center (DTIC). The MATRIS Office collects, stores, updates, retrieves and disseminates information on people-related research. To increase its effectiveness in these activities, the MATRIS Office developed the *MATRIS Indexing and Retrieval Thesaurus (MIRT).*[6] This MIRT is an example of our concept of a useful micro-level thesaurus of the DT&SM K&I contained in a SOURCE's major organized collection. The MIRT consists of a hierarchical list of indexing terms with definitions for the indexing terms, to enable consistent accurate classification of all K&I items indexed in the MATRIS database, and a Keyword Out of Context (KWOC) to aid timely selective retrieval of K&I from the database.

4. Initiate **DoD development and maintenance** of an on-line **DoD DT&SM Glossary** (and subset area glossaries) that provides current authenticated **definitions** for **each term in the DT&SM Thesaurus Structure**, or an **operational description of the concept** represented by each term. Each SOURCE should also develop a companion glossary for the on-line micro-level thesaurus that it develops, and each SOURCE's glossary should be added to the on-line DoD DT&SM Glossary. These glossaries would serve as a basis for an increasingly common defense systems management language throughout the DT&SM community.

The rest of our paper will provide background and information to help understand why it is crucial that the USD(A&T) immediately initiate development of the DoD macro-level thesaurus structure for DT&SM, and vigorously support the three applications of the structure outlined above.

The ultimate objective of a complete DT&SM thesaurus structure (comprised of both the DoD macro-level DT&SM thesaurus structure and the hundreds of evolutionary SOURCE-developed micro-level thesaurus structures extending down from the DoD macro-level structure) is to provide a growing universal structure of preferred DT&SM terms for the DT&SM community. DT&SM professionals in government, industry or academia can then use this common thesaurus structure and its applications:

a. To uniformly classify, organize, and index the widely distributed body of DT&SM knowledge and information (K&I) available in every SOURCE's organized collections of DT&SM K&I.

b. To readily locate available pertinent SOURCEs, when needed; and then to access the most pertinent SOURCEs, and selectively retrieve specific, timely, relevant DT&SM K&I for coping with the professional's DTM or DSM task at hand.

c. To make progress toward a truly common DT&SM language, since the DT&SM indexing terms chosen will be the terms used regularly by the professionals in managing their DTM or DSM tasks. This common language will enable DT&SM professionals throughout the DT&SM community, to communicate unambiguously and with understanding, in planning, coordinating and carrying our their respective DTM and DSM tasks throughout the life cycle of every defense system.

We will also address why developing and applying this DT&SM thesaurus structure can enable more effective use of the Information Highway to achieve integrated management of defense technology and systems over the life cycles of defense systems.

INTEGRATION CONCEPTS

DSM Concept. In our paper four years ago, "Achieving Excellence in Management of Defense Systems," we identified the need for and benefits of extending the domain of Defense Systems Management (DSM)[7] to cover all three stages of the life cycle of each defense system—not only its acquisition, but also its operational employment support (including field updates and modifications) and its final disposition. We recognized that the boundary barriers between each stage are the result of significant differences in the "culture," language and primary objectives of the professionals working in each stage. These differences have caused serious disconnects and misunderstandings, and wasteful discontinuities in the system management processes when each defense system is transferred to the next stage in its life cycle. These differences have impeded feedback of lessons-learned knowledge and operational information from later stages, which could improve substantially the conception, design and production of new systems. These differences have also impeded "feed forward" of new technology K&I to enable more timely cost-saving modification and update of current operational systems to enhance their technological superiority and continued operational suitability and effectiveness. These differences still impede multidisciplinary concurrent engineering aimed at the simultaneous integration of all life cycle elements, such as producibility, reliability, and maintainability, into the systems design process.

Our analysis showed that extending the domain of defense systems management throughout the entire life of each defense system would give significant payoffs—in enhanced operational suitability and operational effectiveness of each defense system, and in dollars saved, more productive defense systems management practices, and improved systems management education.

We used "systems thinking" to define and discuss the Defense Systems Management (DSM) domain that included and extended beyond the acquisition stage to cover each system's life cycle. We discussed the boundaries of the DSM domain, and how they spanned both a great national security managerial hierarchy, and a long DSM time line from initial conception to final disposition of each system. The managerial hierarchy ranges from establishing national defense policies that involve defense systems, down through numerous DoD and other government organizational hierarchies to the management level(s) where these policies are finally executed for each system.

The top part of Figure 1 is a 1993 updated portrayal of our 1991 concept of Defense Systems Management (DSM). Its upper part portrays our view of management over a defense system's life cycle, with three consecutive management stages: acquisition, operational employment support, and final disposition. It also portrays K&I Process Systems that are required to support the managers in each stage. Three process systems which cross stage boundaries and need K&I feedback and "feed forward" across the boundaries are identified. They concern system test and evaluation (DT&E and OT&E), man-machine integration management (M-MIM) to achieve most effective performance of the total operational system, and logistics and infrastructure support management (L&ISM). There are many other K&I process systems. Many already exist, others should be developed, and all need to be integrated. This portrayal of DSM also identifies some of the many kinds of DSM knowledge and information in various major organized collections of SOURCEs that a DoD Macro-level DT&SM Knowledge Locator System could help locate and access.

The boundaries between DSM stages are the result of some significant differences in the objectives and "culture," and thus differences in the language (terms used in communication) by the professionals working in each stage. Disconnects and misunderstandings in communications, and discontinuities in management processes, result when professionals working in a particular process that crosses a stage boundary (e.g., the L&ISM—Logistics and Infrastructure Management process) don't have a completely common language (i.e., common concepts, with each concept represented by its own commonly understood

term). Integrating the DSM stages will be difficult, if not impossible, without common concepts and a common working language for all stages of each system's life cycle. The recent new requirement outlined next, to integrate DTM with every stage of DSM greatly increases the urgency of achieving common concepts and a truly common language for integrated Defense Technology and Systems Management (DT&SM).

DEFENSE SYSTEMS MANAGEMENT (DSM) over the Life Cycle of Each Defense System		
ACQUISITION DSAM Stage	OPERATIONAL EMPLOYMENT SPT OESM Stage	DISPOSITION DSDM Stage
DSM K&I (knowledge & information) Process Systems		
DSAM K&I DT&E K&I M-MIM K&I L&ISM K&I	OESM K&I OT&E K&I M-MIM K&I L&ISM (ILSM & ISM) K&I	DSDM K&I ILSM K&I
Kinds of K&I Provided by DSM K&I Locator Systems		
Milestones 0–IV Phases I–IV FMPT&S Prog L & IS Planning	Operational Test & Evaluation Man-Machine Integration Integ Logistics Spt & Infrastructure Spt	Foreign Military Sales Recycle/Salvage Environmental clean up
DEFENSE TECHNOLOGY MANAGEMENT (DTM) throughout Defense Systems Management Cycle		
Kinds of DTM K&I Process Systems		
Advanced Concept Technology Demonstrations (ACTDs) Exploratory & Advanced Development Efforts in 19 Technology Plan Areas Basic Research Efforts in 12 Militarily Relevant S&T Areas		

Figure 1. Integrated DEFENSE TECHNOLOGY & SYSTEMS MANAGEMENT (DT&SM)

DTM Concept.

Defense Technology Management (DTM) is an evolutionary new concept. It began evolving in the post cold-war environment from the traditional program of Research, and Exploratory and Advanced Development. For many years this R&D program, although not formally recognized as part of defense systems acquisition management, has provided most of the technology needed in acquisition of new defense systems. Now, shrinking Defense budgets, prospects of technological surprise, and emergence of many different and unforeseen threats in the post-Soviet world, have expedited evolution of this new concept that DTM is an integral part of life-cycle defense systems management. The importance of the new DTM concept is evidenced by the recent addition of Technology in the title of Under Secretary of Defense for Acquisition (USDA), now the short title is USD(A&T).

On 5 October 1994, the Deputy Secretary of Defense and the Director of Defense Research and Engineering (DDR&E), announced this Administration's new Defense Science and Technology (S&T) Program, and the new *Defense Science and Technology Strategy* and *Defense Technology Plan* [3] for implementing it. The vision of this S&T program is to "Develop and transition superior technology to enable affordable, decisive military capability and to enhance economic security." The program intends to improve productivity, reduce costs, and above all assure technological superiority.

The aspects of science and technology that the DoD pursues in the S&T program, and with what priority, will be determined by our military needs, recognizing that the program's content will be constrained by limited budgets. Five Future Joint Warfighting Capabilities have been identified by the Joint Staff and the Joint Requirements Oversight Council as most needed by the U.S. Combatant Commands.

Two strategic investment priorities, both new to the Defense S&T program, will maximize the extent that the S&T vision can be achieved within budget constraints. One, with specific exceptions for some critical defense-unique technologies such as nuclear weapons and missile guidance, is the priority for dual-use technology development. This

contributes to building a common commercial and defense industrial base, which will serve most defense needs better and also enhance U.S. economic competitiveness.

The second is to consider affordability as an integral part of the S&T program. In the past, the threat demanded and the budget permitted the S&T program to focus on increased performance along all warfighting dimensions, e.g., fighter aircraft speed, cold weather endurance, radiation hardness. Today, materiel and systems must be developed at lower cost, be longer-lived, and be incrementally enhanced through planned upgrades. Based on analysis of the capabilities that the Combatant Commands need most and the technological opportunities that exist today, priority will be placed on three technology areas: information science and technology, modeling and simulation, and sensors.

The S&T program is traditionally described as having three separate and identifiable elements: Basic Research, Exploratory Development, and Advanced Development. It functions, however, as a continuum to advance technology, with the Advanced Technology Development program structured to apply technological advances to provide military capability. In the *Defense Technology Plan,* technology efforts are structured into nineteen areas. This plan, updated annually, will be used to manage development and application of new technology to provide adequate defense capability.

As indicated earlier, the vision of the S&T program is to improve productivity and reduce costs, and above all assure technological superiority. Achieving this involves managing technology development and application to assure technologically superior defense capabilities. In our paper we call this Defense Technology Management (DTM).

In Figure 1, we have portrayed DTM and Defense Systems Management (DSM) as integral parts of integrated Defense Technology and Systems Management (DT&SM). As an integral part of DT&SM, DTM begins before the acquisition stage, before the start of any defense system's life cycle, and seeks to assure the technological superiority of new system acquisitions. DTM continues interacting with DSM during each DSM stage to assure continued military superiority, and sustained operational suitability and effectiveness of each defense system throughout its life cycle.

The objective of the underlying Defense Basic Research program in DTM is to produce knowledge in a science or engineering area that is militarily relevant. It is a long term investment with emphasis on opportunities far into the future. The current program's investments are in twelve scientific and engineering areas listed in *Defense Science and Technology Strategy*. The program intends to be a source of new knowledge that may be recognized as militarily relevant at some point in the DSM life cycle.

Exploratory Development and Advanced Development mature technologies. Exploratory Development, which may include prototypes embodying a technology, takes research results and provides proof of concept experiments and evaluations built around models and laboratory experiments. The Advanced Technology Development program is structured to apply technology advances to provide military capability. Current technology efforts are structured in the *Defense Technology Plan* into nineteen technology areas for oversight purposes. Specific results of these experiments and technology efforts also may be found applicable and put to use at any point in the DSM life cycle.

Advanced Concept Technology Demonstrations (ACTDs) are a new aspect of the S&T program. They are the focused successors of the seven broad S&T thrusts pursued over the past few years. ACTDs are tightly focused on specific military concepts. They are user-oriented with three motivations: (1) to have the user gain an understanding of an ACTD's military utility, and to evaluate it before committing to acquisition; (2) to develop corresponding concepts of operation and doctrine that make best use of the new capability; and (3) to provide residual operational capability to the forces. The outcome of an ACTD, and whether or not an ACTD

initiates acquisition as a new system, or as a technological upgrade of an operational system, is judged by its operational users. ACTDs are a focused means of integrating DTM into DSM over a system's life cycle.

Integrated DT&SM Concept. The vision is that DTM and DSM will become truly integral parts of the whole integrated process for managing defense systems throughout their life cycles—integrated DT&SM (Defense Technology and Systems Management). The problem is how to accomplish an integrated DT&SM and best assure real operational integration of all DTM and DSM K&I in order to achieve affordable, technologically superior, and environmentally safe defense systems throughout every stage of their life cycles.

Figure 1 portrays four different major processes that must be performed, first in managing defense systems over three stages of their life cycles (DSM), and then as of October 1994, concurrently managing technology (DTM) and integrating it into each stage. Integrating DTM into DSM aims to reduce costs of the systems in each stage, while also assuring their technological superiority throughout their life cycles in the changing and uncertain post-Soviet environment.

Long standing organizational attempts to overcome the barriers between these major processes have been largely unsuccessful. However, a new paradigm is emerging. The *Acquisition Management Integrated Weapon System Management (IWSM) Guide,*[8] 1 October 1993, describes how the Air Force Materiel Command (AFMC) is addressing overcoming these barriers with its new (IWSM White Paper, January 1992) and still evolving IWSM concept. The concept is designed to provide single product management for all aspects of a system throughout its life cycle—from cradle to grave. One key IWSM principle is Integrated Product Teams (IPT) with their cross-functional representation and product emphasis to achieve an effective total systems approach. We believe that IWSM represents a great step in overcoming barriers between the four different major processes. It should be emulated throughout the DT&SM community. The IWSM concept of Integrated Product Teams (IPT) seems to fit David Packard's criteria for *centers of management excellence.*[9]

However, in implementing IWSM, AFMC is encountering, a real barrier to integration —lack of a common language among all functions involved. And to be effective, the IWSM Integrated Product Teams still face the universal problem of getting timely knowledge and information relevant to tasks at hand. Implementing our proposed initiatives should help IWSM programs cope better with both problems.

We believe that truly integrated DT&SM are necessary for cultivation of the *centers of management excellence* which Chairman David Packard, in his Foreword to the 1986 Packard Report, stated is required in the large complex enterprise of national defense.

Integrated DT&SM can (a) provide the integrated DSM and DTM K&I required to cultivate *centers of management excellence* throughout the DT&SM community, and (b) provide to the professionals in each *center*, timely and selective on-demand access to relevant DSM and/or DTM K&I that each professional requires for five main purposes:

1. To continually know and have a common understanding of the goals and objectives of DoD's centralized policies.
2. To clearly coordinate each center's respective efforts in its area of responsibilities, toward coordinated execution of the commonly understood centralized defense systems management policies, in order for all to contribute productively to achieving DoD's goals and objectives for assuring our national defense.
3. To develop and maintain job- and task-related specialized know-how.
4. To explore new and better ways for getting each professional's job done.
5. To perform with excellence any DSM or DTM management task at hand.

Truly integrated DT&SM requires and depends upon IMT-enabled "informational" integration of all DSM and DTM K&I required by DT&SM professionals for their DSM or DTM management tasks in any aspect of a defense system's life cycle. No

other practical alternative is available. Changes in organizational structure and processes may correct some authority-responsibility deficiencies (while creating others). However, they do not solve the problems of assuring timely access, by DT&SM professionals working in any part of a defense system's life cycle, to selected DSM and/or DTM K&I that are relevant for a systems management task at hand.

In the complex bureaucracy concerned with national defense, integrated DT&SM cannot be achieved organizationally. But, it can be achieved operationally—by applying new information management technologies (IMT) to achieve "informational" integration of DT&SM K&I.

The need for integrated DT&SM K&I is critical, given the limited defense budget outlook and the present world environment. We see no alternative to IMT-enabled "informational" integration of DT&SM K&I that are widely distributed throughout the DT&SM community (government, industry and academia). Considering both we identify some IMT elements that should be considered in progressing toward integrated DT&SM.

IMT TOOLS

Information Highway. Much of the information highway that already exists can be used by professionals throughout the DT&SM community: to quickly obtain for management tasks at hand, relevant DTM and DSM K&I from pertinent widely distributed organized collections of SOURCEs, and to coordinate their systems management actions.

What these professionals need now are: (a) better DT&SM on- and off-ramps to connect each professional to all organized collections of DTM and DSM K&I that are maintained by SOURCEs; (b) better guidebooks for first locating pertinent SOURCEs; and then, for selectively accessing the organized collections of pertinent SOURCEs, and retrieving K&I that are relevant for a task at hand; and (c) a common DT&SM language for communicating with understanding in coordinating their management actions to assure technologically superior, and operationally suitable and effective defense systems throughout each system's life cycle.

Like any useful highway, a key factor that makes the information highway useful is the standards that are applicable to its component elements. As part of the U.S. National Information Infrastructure, the Federal government has established the Government Information Locator Service (GILS) Standard to help the public locate and access government information (e.g., economic data, environmental data, technical information). OMB Bulletin No. 95-01, dated December 7, 1994, established the GILS. The National Institute of Standards and Technology (NIST) issued Federal Information Processing Publication (FIPS Pub) 192, dated December 7, 1994, to announce the standard for the Application Profile for the GILS—a voluntary international standard with mandatory application for Federal agencies establishing locators for information. This standard must be considered in the proposed development of the DoD Macro-level DT&SM Knowledge Locator System.

Many who are users, or who are at least aware of Internet, recognize that Internet is an integral part of today's information highway, and that it is completely open to the public world-wide. They may be wary about developing better DT&SM on- and off-ramps, and better guidebooks for accessing DT&SM K&I, because they fear adverse effects from using these tools on Internet and on other aspects of the information highway that are completely open to the public. This fear about using IMT to develop and use these new systems management tools is not warranted.

The U.S. intelligence community has created its own Internet, dubbed Intelink,[10] which is based on the same technology used to run and navigate the original Internet. This new Intelink network for sharing supersecret information, officially began operating in late 1994. When the bugs are worked out and the final system is in place, it will allow analysts, policymakers, and workers in the field who have Top Secret security clearances, to

tap quickly and directly from their own computers into classified information in various parts of the national security bureaucracy.

We do not expect Intelink to be available for defense systems management. However, much of the technology used to run and navigate Intelink can be used to quickly develop a DT&SMlink network, when the DT&SM on- and off-ramps, the DT&SM guidebooks and a common DT&SM language are developed and ready to be used on a DT&SMlink network to manage defense systems throughout their life cycles.

Thesaurus Structure. Developing a DoD Macro-level DT&SM Thesaurus Structure is prerequisite to all other initiatives we proposed at the beginning—initiatives for developing tools that can enable increasingly integrated, less costly, and more effective management of defense systems to assure their continued operational effectiveness over their life cycles.

This DT&SM thesaurus structure is essential: to the development of DT&SM on- and off-ramps to the information highway, to development of guidebooks for accessing and retrieving relevant K&I, to development of a common DT&SM language for communicating and managing defense systems more effectively, and will have other uses in the integration of DT&SM K&I. The DT&SM thesaurus structure is key to "informational" integration of DT&SM K&I.

The **thesaurus structure**, in the context of this paper, is a vocabulary of controlled indexing language. The structure will also be used as a retrieval language. It comprises the terms used by DT&SM professionals in communicating and coordinating their respective efforts in performing two major types of management tasks to achieve DT&SM objectives:

- DSM tasks in managing defense systems throughout their life cycles, including their acquisition, test and evaluation, man-machine integration, upgrade, operational training, logistical and infrastructure support, and final disposition.
- DTM tasks in managing militarily relevant science research and technology development, to achieve new technological advances that may be required, in the acquisition of a new defense system, or in a system's upgrade or field modification during any stage of its life cycle, to assure its affordability, technological superiority, environmental safety, and operational effectiveness.

The best IMT aid we have found for planning development of the DoD Macro-level DT&SM Thesaurus Structure is the book, *Thesaurus Construction*,[11] published in 1987 by The Association for Information Management in London. Among items a useful thesaurus structure should include, it discusses the following three types of relationships among indexing terms.[12] The relationships are defined by ISO Standard 2788.

- Equivalence—"the relationship between preferred and non-preferred terms where two or more terms are regarded, for indexing purposes, as referring to the same concept." The preferred term is the one chosen to represent the concept for indexing. The non-preferred terms form an entry vocabulary directing the user to the preferred term. The following conventions are used to express the reciprocal relationship: UF (use for) written as a prefix to the non-preferred term; USE written as a prefix to the preferred term.
- Hierarchical—shows "levels of superordination and subordination. The superordinate term represents a class or whole, and the subordinate terms refer to its members or parts." This relationship is a basic feature of a thesaurus, distinguishing it from unstructured term lists. The following conventions are used to express the reciprocal relationship: BT (broader term) written as a prefix to the superordinate term; NT (narrower term) written as prefix to the subordinate term.
- Associative—shows terms that are related, but in a way other than described in the two previous relationships (e.g., two quite different processes may be associated by both being required to complete a task). The reciprocal relationship is distinguished by the abbreviation RT (related term) for associated terms.

The DT&SM two-level thesaurus structure will comprise:

- One DoD macro-level DT&SM thesaurus structure—to be used first to develop a DoD Thesaurus of Available SOURCEs of DT&SM K&I—that can help locate all available organized special collections of K&I, distributed widely throughout the DT&SM community. (See Locator System in next section.)
- Numerous micro-level thesaurus structures—each developed by the SOURCE of an available organized collection of DT&SM K&I—which will become evolutionary extensions down from lowest hierarchical-level terms of the DoD macro-level DT&SM thesaurus structure.

As explained above in the third proposed initiative, each SOURCE should develop its own micro-level thesaurus structure and a thesaurus of the special DT&SM K&I that are available from the SOURCE's organized collection.

The *MATRIS Indexing and Retrieval Thesaurus (MIRT)* [6] is described earlier under the third proposed initiative, as an example of our concept of a useful structured micro-level thesaurus of the DT&SM K&I available from a K&I SOURCE. The MATRIS Office developed its *MIRT* to improve indexing and retrieval of the K&I that are available in the MATRIS database—manpower and personnel, education and training, simulation and training devices, and human factors engineering K&I. The *MIRT* includes three presentations of its thesaurus structure:

- MIRT Hierarchical List of Indexing Terms
- MIRT Definitions of Indexing Terms
- MIRT Keyword Out of Context (KWOC)

These *MIRT* presentations will be maintained and used by the MATRIS Office to collect, store, update, retrieve and disseminate information on people-related research in its database.

No example exists of the proposed DoD macro-level DT&SM thesaurus structure. Nor can one be constructed from the bottom up (i.e., from the micro-level thesauri of K&I available in the organized collections maintained by all SOURCEs), since the location of all SOURCEs is not yet known, and many SOURCEs have not developed a structured thesaurus. The DoD macro-level DT&SM thesaurus structure must be constructed from top down.

In 1991 we proposed development of a Defense Systems Acquisition Management (DSAM) Taxonomy-Glossary. The purpose of the DSAM Taxonomy-Glossary was to provide the structure for a DSAM Structure & Information System (DSAM-SIS).[13] We proposed developing the DSAM-SIS as a useful tool for DSAM professionals. Those DSAM professionals in charge of organized DSAM collections could use its Taxonomy-Glossary <u>Structure</u> to classify and index the K&I in their respective DSAM collections. Then, all DSAM professionals could use its <u>Information System</u> to access any of these widely distributed Taxonomy-indexed organized DSAM collections, and selectively retrieve relevant DSAM K&I for a task at hand. Once the usefulness of DSAM-SIS was demonstrated in acquisition, we believed it would be extended to cover the other DSM life-cycle stages.

The completely revised DODD 5000.1, "Defense Acquisition," and DODI 5000.2, "Defense Acquisition Management Policies and Procedures," were issued, February 23, 1991. We began planning to use digitized versions to construct a DSAM Taxonomy-Glossary (basically a DSAM thesaurus structure). The terms and associated definitions in DODD 5000.1 and DODI 5000.2 were terms that DSAM professionals use in communicating and coordinating their DSAM tasks and acquisition efforts. So a useful DSAM Taxonomy-Glossary uses these terms and definitions as the vocabulary of its controlled indexing language.

Using *Thesaurus Construction* [11] as the guide to construct the DSAM Taxonomy-Glossary would require a large manual effort. It was written in 1987 before great advances in personal computer software. Since 1991 we have been searching widely, even at the Library of Congress, for information about computer utilities specifically

designed to facilitate thesaurus construction. We recently queried the publishers of *Thesaurus Construction.* They told us that the 1987 edition is still the current edition, but gave us a list of four PC software packages which aid construction of thesauri. We obtained a demonstration copy of one, *Term Manager: Structured Thesaurus System*[14] for constructing and maintaining thesauri. We planned to use *Thesaurus Construction* and the demo version of *Term Manager*, with a digitized version of DODD 5000.1 and DODI 5000.2 as sources of indexing terms and definitions, to build a small demo DSM macro-level thesaurus-structure model.

When we obtained a hard copy of *MIRT* in November 1994, we considered trying further to design our DSM macro-level thesaurus-structure model, such that *MIRT* could be viewed as a micro-level thesaurus structure that extended down from our demonstration DSM macro-level thesaurus structure. However, late receipt of both *Term Manager* and *MIRT*, coupled with an unrelated emergency two months before due date, prevented developing a demonstration DSM macro-level thesaurus structure in time for this paper.

Nevertheless, we strongly recommend that the Under Secretary of Defense for Acquisition and Technology (USD(A&T)) initiate development of the DoD Macro-level DT&SM Thesaurus Structure, considering all SOURCEs of available organized collections of DT&SM K&I that are widely distributed throughout the DT&SM community, in government, industry and academia. This thesaurus structure is the key management tool for integrating DT&SM, beginning with its use and application in the other three initiatives proposed in the Introduction.

Knowledge Locator System. The body of DT&SM knowledge and information (K&I) is enormous, and widely distributed in thousands of different organized collections of particular categories of DT&SM K&I (i.e., SOURCEs), throughout the DT&SM community—throughout the DOD and other government organizations, industry and academia. As referenced in the Introduction, the term K&I SOURCE, or SOURCE, is used in this paper to indicate any organized collection of DT&SM K&I (e.g., a special library, repository, archive, database, center of expertise, information analysis center) that is available for access by DT&SM professionals to retrieve specific K&I that are relevant to a task at hand. These are collections that:

- Concern different subject areas of DT&SM K&I (e.g., for DTM—research, technology demonstrations; or for DSM—systems engineering, test and evaluation, logistics support),
- Use many different storage media (reports, books, articles, electronic data, CD-ROM discs, human expertise), and
- Are assembled to support many different DT&SM purposes and functions.

DT&SM professionals need timely, selective, on-demand access to specific DT&SM K&I, available from the widely distributed K&I SOURCEs, that are relevant to any of the five management purposes identified above under Integrated DT&SM Concept.

Considering (a) the enormous size of the body of DT&SM K&I, and its wide distribution throughout the DT&SM community, in thousands of SOURCEs (with organized collections that treat different K&I subject areas of the body of DT&SM K&I), and (b) the pervasive K&I access needs of DT&SM professionals: **How best can all of these items of DT&SM K&I be identified, organized, classified, stored, and indexed at a K&I SOURCE, for timely selective on-demand access and retrieval by DT&SM professionals throughout the DT&SM community?**

Our answer after much research and analysis is: Begin to implement a DT&SM Knowledge Locator System, that has two levels of search for relevant K&I:

- Macro-level—concerned with the organizational name, location and contact point of each available K&I SOURCE, the main DT&SM subject categories of the K&I in its K&I collection, and the media used to store the collection which determines how the collection will be accessed.
- Micro-level—concerned (after a pertinent SOURCE is located) with timely,

selective, on-demand access to, and retrieval of relevant K&I from the organized K&I collection of the SOURCE.

Progress on the first initiative proposed above—developing a DoD Macro-level DT&SM Thesaurus Structure (discussed under Thesaurus Structure)—is required to effectively implement both levels of the DT&SM Knowledge Locator System.

Progress on the second proposed initiative—developing an on-line DoD Macro-level DT&SM Knowledge Locator System—is contingent on using the DoD Macro-level DT&SM Thesaurus Structure to develop an on-line DoD Thesaurus of Available SOURCEs of DT&SM K&I. This Thesaurus of Available SOURCEs is the foundation for an on-line DoD Macro-level Knowledge Locator System, which any DT&SM professional can use to search for and locate pertinent SOURCEs—those most likely to have a K&I collection which contains K&I that are relevant to the professional's task at hand. The professional must first find the most likely useful SOURCEs, before he or she can employ IMT aids to get timely, selective, on-demand access to a located SOURCE's organized collection, and retrieve specific relevant K&I.

Progress on the third proposed initiative—that each SOURCE develop an on-line micro-level thesaurus of the particular DT&SM K&I maintained in its own organized K&I collection—will take some time after the on-line DoD Macro-level DT&SM K&I Locator System is operational. So, if an on-line micro-level thesaurus is not yet available in a pertinent SOURCE found with the on-line Locator System, the DT&SM professional can work with the SOURCE's collection managers and use the SOURCE's current system for providing users access to its K&I collection.

But when the SOURCE has an on-line micro-level thesaurus of its K&I collection, the professional can use this thesaurus to directly access and retrieve from the SOURCE's collection, specific documents, data, and/or consultant expertise that are relevant to the professional's task at hand.

Glossaries & Common Language. The fourth proposed initiative—DoD development and maintenance of an on-line **DoD DT&SM Glossary**—should begin in parallel with the first initiative—DoD developing a DoD Macro-level DT&SM Thesaurus Structure—by adding each term in the macro-level thesaurus structure and its definition to the DT&SM glossary. Progress should continue by adding to the DT&SM glossary, the glossary that each SOURCE develops as a companion to the SOURCE's thesaurus of its organized collection of DT&SM K&I.

The DoD DT&SM Glossary and the growing number of SOURCE glossaries will promote development of an increasingly common defense systems management language throughout the DT&SM community. The increasingly common language will help avoid serious errors and costly reworks due to misunderstandings, and will aid unambiguous communication among DT&SM professionals in their coordination of tasks over a system's life cycle, to get systems management tasks and programs done right the first time.

Organized Collections. The on-line DoD Thesaurus of Available SOURCEs of DT&SM K&I, and thus the DoD Macro-level DT&SM Knowledge Locator System, will include all available organized collections of DT&SM K&I that can be found throughout the DT&SM community. Many nearly identical K&I collections—developed before the information highway and current IMT tools for remote access were available—may be unnecessarily duplicated in more than one SOURCE.

We believe that USD(A&T) implementation of our proposed initiatives will yield **enormous savings** as unnecessary duplication of major organized collections of DT&SM K&I are found during development of the on-line DoD Thesaurus of Available SOURCEs of DT&SM K&I. We are suggesting not only enormous **dollar savings** in duplicated information dissemination operations, and in duplicated people, equipment and facilities throughout the DT&SM community, in DoD and other government

organizations, industry and academia—but also, **opportunity cost savings** of management time now spent searching for relevant DT&SM K&I, of relevant K&I now missed for lack of awareness of pertinent K&I SOURCEs, and from not being able to get timely access to the most relevant K&I for tasks at hand.

Three categories of organized DT&SM K&I collections are considered here for two reasons. First, they provide examples of what we mean by organized K&I collections. Second, we believe that each of these categories are particularly useful in achieving "informational" integration of DT&SM. They should become more widely known through the DoD Macro-level DT&SM Knowledge Locator System. Thus, their K&I will be more readily available to all DT&SM professionals in any of the four main DT&SM processes represented in Figure 1 (i.e., acquisition, operational employment support, disposition, and defense technology management), not just to those who work regularly with each collection.

One category, distributed throughout the DT&SM community, are the K&I databases of CALS, initially (Computer-Aided Acquisition and Logistics Support), but with increasing emphasis on life-cycle systems management, now also (Continuous Acquisition and Life-cycle Support). These CALS K&I databases are the result of government-industry development during the past five years, of CALS computer program standards for indexing, storing, transferring, and retrieving data concerning defense systems, parts, drawings and manufacturing. CALS focuses mainly on DSM K&I, but these K&I are also useful to DT&SM professionals working in DTM.

Another category is the Defense Technical Information Center (DTIC) collections, including its Technical Reports collection which also includes many acquisition documents, its Work Unit Information System (WUIS) and Independent Research and Development (IR&D) databases, its Information Analysis Center (IAC) program, and other Science and Technology (S&T) programs. Formerly, DTIC's organized collections focused mainly on traditional Science and Technology R&D. With the October 1994 announcement of the new *Defense Science and Technology Strategy* and *Defense Technology Plan,* we believe these S&T and other collections will have an expanded role in DTM, and in increased DTM integration with DSM for system upgrades throughout the life cycle of defense systems.

In the third category, the *Air Force Acquisition Model (AFAM)*[15] is a unique powerful new software package, an organized collection of automated systems acquisition process how-to K&I. AFAM is a vehicle by which functional experts in the Air Force Materiel Command (AFMC) provide insight on procedures, best practices, and lessons-learned wisdom needed to complete over 4000 acquisition tasks and subtasks throughout the entire acquisition process. Information provided for each task includes: acquisition relationships (past, current and future tasks), references to additional K&I, wisdom (best practices, lessons-learned, expert opinion), tools (templates, courses, software), and a timeline estimate of task length.

The AFAM software package also includes a supplemental package (another organized collection), called the Air Force Acquisition Model Supplement (AFAMSUP). It is a text retrieval system that currently houses over 113 current documents—DODD 5000.1 and DODI 5000.2, DoD MIL-STDs, Air Force Regulations and AFMC acquisition documents.

AFAM is designed to bring far more comprehensive "expert" experience into Air Force acquisitions when it is most needed—at the beginning. AFAM runs on an IBM-compatible personal computer, as a stand alone or on a Local Area Network (LAN). The numerical statistics for tasks and documents stated above are for AFAM Version 2.0, 1 September 1994. Each subsequent version, released every 180 days, will add more enhancements and data to reflect the best current practices and corporate knowledge changes.

We believe that AFAM is a model that other Military Services and agencies could adapt in order to identify their respective tasks and DT&SM documents useful to their program management offices and others in the life-cycle management of their defense systems.

We also see the AFAM model of acquisition tasks and its DoD 5000.1 and 5000.2 documents, as very useful in our first proposed initiative—developing a DoD Macro-level DT&SM Thesaurus Structure. The DoD documents would be sources of terms and concept definitions, and the task statements would help identify associative relationships among processes that are otherwise unrelated, but are required together to complete a task.

In addition, the AFAM's easy customer feedback to shape, refine and enhance future releases of AFAM is a good model for getting feedback to continually improve the IMT-aided management tools. For example: to increase the usefulness of the terms used in successive releases of the DoD Macro-level DT&SM Thesaurus Structure, and to find additional available K&I SOURCEs to expand and improve the DoD Thesaurus of Available SOURCEs of K&I.

SUMMARY

The present world and national environment requires substantial changes in the process of managing defense systems—changes from managing separately the four processes portrayed on Figure 1, (DTM and the three successive DSM stages of each system's life cycle), to integrated Defense Technology and Systems Management (DT&SM) throughout every system's life cycle.

Recent advances in computer and other information management technologies (IMT) can make "informational" integration of DT&SM a practical reality. Truly integrated DT&SM will not only reduce costs, but also best assure: increased rationalization, standardization and interoperability of DT&SM processes and products, the continued technological superiority of our defense systems, and sustained system operational suitability and effectiveness in all stages of their life cycles. It would also help AFMC's IWSM develop a common language for life-cycle management of Air Force systems.

To start progress toward this goal, we propose four initiatives by the Under Secretary of Defense for Acquisition and Technology (USD(A&T)) to begin development of IMT-aided tools that will enable achievement of integrated DT&SM. Ultimately, these tools will enable any DT&SM professional to directly access pertinent K&I SOURCEs throughout the DT&SM community, and selectively retrieve specific DSM or DTM K&I that are relevant to the professional's task at hand. The initiatives are:

1. Initiate immediate development of an on-line [5] DoD Macro-level DT&SM Thesaurus Structure. This thesaurus structure is the key management tool for integrating DT&SM, beginning with its use and application in the following proposed initiatives:

2. Then, initiate development of an on-line DoD Macro-level DT&SM Knowledge Locator System, based on a DoD Thesaurus of Available SOURCEs of DT&SM K&I that are distributed throughout the DT&SM community, in the DoD and other government organizations, industry and academia. Once operational, any DT&SM professional can use the Locator System to quickly locate increasing numbers of available SOURCEs of DT&SM K&I that may have specific K&I the professional needs for a task at hand.

3. Encourage evolutionary extension of the on-line DoD Macro-level DT&SM Thesaurus Structure down into every K&I SOURCE included in the Knowledge Locator System, by encouraging every SOURCE to develop an on-line micro-level thesaurus and a companion glossary of the special K&I available in the SOURCE. These new on-line micro-level thesauri will enable any DT&SM professional to use the information highway (for example, the DT&SMlink suggested above), not only to locate pertinent SOURCEs of likely useful K&I, but also to directly access the SOURCE's on-line thesaurus and retrieve K&I that are relevant to a task at hand.

4. Initiate DoD development and maintenance of an on-line DoD DT&SM

Glossary (and subset area glossaries) that provides current authenticated definitions for every term in the DT&SM Thesaurus Structure. Each companion glossary (for the micro-level thesaurus that each SOURCE develops for its collection of K&I) should also be added to the on-line DoD DT&SM Glossary. As these glossaries become more comprehensive they will support development of an increasingly common defense systems management language throughout DT&SM community. This will enable better communication with understanding among DT&SM professionals and more effective coordination to get systems management tasks and programs done right the first time.

Thus, the DoD DT&SM macro-level thesaurus structure will: support development of DT&SM on- and off-ramps to the information highway (e.g., Knowledge Locator System), aid development of guidebooks for DT&SM K&I SOURCEs (e.g., micro-level K&I thesauri), promote development of a common DT&SM language (e.g., DT&SM glossaries), and enable more effective use of information management technologies to achieve integrated life-cycle management of defense technology and defense systems.

ENDNOTES

[1] Mathias, John R., and Mosier, Andrew P. 1991. "Achieving Excellence in Management of Defense Systems." *Proceedings, 1991 Acquisition Research Symposium*, Vol. II, pp. 223–236. (Note: The last two pages of this paper, inadvertently omitted from the *Proceedings,* should be available from DSMC. If not, Dr. Mosier can provide them as pages 236a and 236b.)

[2] Mosier, Andrew P., and Mathias, John R. 1993. "Acquisition Knowledge & Information Locator System." *Proceedings, 1993 Acquisition Research Symposium*, pp. 451–462.

[3] U.S. Department of Defense, Director of Defense Research and Engineering. September 1994. *Defense Science and Technology Strategy* and *Defense Technology Plan.* Washington D.C.: GPO.

[4] To simplify discussion in this paper, the terms K&I SOURCE, or SOURCE, are used to indicate any available major organized collection of DT&SM K&I (e.g., special library, repository, database, center of DTM or DSM expertise, maintained by an organizational SOURCE). These organized K&I collections are widely distributed throughout the DT&SM community—in the DoD and other government organizations, industry and academia.

[5] The term on-line in this paper, includes the alternative, on CD-ROM discs.

[6] MATRIS Office, Defense Technical Information Center. August 1994. *MATRIS Indexing and Retrieval Thesaurus (MIRT).* San Diego, CA: DTIC, MATRIS Office.

[7] "Achieving Excellence in Management of Defense Systems," pp. 227–231.

[8] Air Force Materiel Command. 1 October 1993. *Acquisition Management Integrated Weapon Systems Management (IWSM) Guide*. AFMCP 800–60. WPAFB, OH: AFMC.

[9] "Achieving Excellence in Management of Defense Systems," pp. 225–227.

[10] "Cloak and Danger Internet Lets Spies Whisper in Binary," *The Washington Post,* 28 December 1994, p. 4A.

[11] Aitchison, Jean, and Gilchrist, Alan. 1987. *Thesaurus Construction*, 2nd Ed. London: Aslib (Association for Information Management).

[12] Aitchison and Gilchrist, pp. 34–50.

[13] "Achieving Excellence in Management of Defense Systems," pp. 234–236.

[14] Business Simulations Limited. 1993. *Term Manager, Structured Thesaurus System,* for constructing and maintaining thesauri. London: Business Systems Limited.

[15] AFAM Program Office, Air Force Materiel Command. 1 September 1994. *Air Force Acquisition Model (AFAM*). WPAFB, OH: AFAM Program Office.

The F-22 Integrated Product Development (IPD) Implementation Improvement Plan

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ABSTRACT

In 1988, the DoD implemented an initiative called Concurrent Engineering (CE) to improve weapon system quality while at the same time reducing both cost and schedule risk. The United States Air Force (USAF) expanded CE concepts to include all disciplines, not just technical, and developed the concept known as Integrated Product Development (IPD). The Air Force Systems Command successfully applied IPD to one of its most important weapon system programs: now the F-22 Advanced Tactical Fighter (ATF). Over the past four years, however, the F-22 Team[1] recognized that a plan for continually improving IPD implementation is necessary to ensure a quality weapon system design. This paper describes the F-22 IPD Implementation Improvement Plan. It outlines the tool and process used by the F-22 Team to measure and improve its implementation of IPD and the overall quality of the F-22 weapon system.

EVOLUTION OF IPD

Concurrent Engineering. In 1986, the President's Blue Ribbon Commission on Defense Management noted that weapon systems take too long to develop, cost too much to produce, and often do not perform as promised or expected.[2] At the same time, private industry was attributing its success in the competitive global market to its use of new integrated design initiatives such as concurrent engineering (CE).[3] US industry reported improved quality of their products and services, decreased costs, and improved adherence to shorter schedules by the use of concurrent engineering approaches. In 1986, the Under Secretary of Defense for Acquisition USD(A) chartered the Institute for Defense Analysis (IDA) to examine the concept of CE.[4] CE has its roots in the integrated design and production practices which emerged in the Japanese auto industry following World War II.[5] CE is defined as:

> *A systematic approach to the integrated, concurrent design of products and their related processes, including manufacturing and support. This approach is intended to cause developers, from the outset, to consider all elements of the product life cycle from conception through disposal, including quality, cost, schedule, and user requirements.*[6]

The IDA studied CE as implemented by fourteen major US. corporations and conducted workshops to learn about the various approaches taken to apply CE in industry. In the final report, the major recommendation by the IDA was that the DoD take positive steps to encourage use of CE in weapon systems acquisition.[7] The IDA concluded that companies which implemented CE practices produced higher quality products at lower cost and in less time than before. Following this recommendation, the DoD and Service acquisition secretaries required implementation of CE into the DoD's weapon systems acquisition process.[8,9]

IPD in the USAF. The Air Force Systems Command[10] expanded on the CE concepts to include all disciplines (e.g. finance, logistics, etc.), not just technical, and named their implementation concept of CE "*Integrated Product Development*" or IPD. The USAF defines IPD as:

A philosophy that systematically employs a teaming of functional disciplines to integrate and concurrently apply all necessary processes to produce an effective and efficient product that satisfies customers' needs.[11]

This modified concept of CE was implemented by Air Force Materiel Command (AFMC). Certain weapon development programs including the F-22 fighter weapon system (others were F-15, F-16, and B-2) were identified within Aeronautical Systems Division (ASD) as test beds for IPD. This expanded concept of CE has been used on the F-22 Advanced Tactical Fighter (ATF) program since the award of the Engineering & Manufacturing Development Phase contract in 1991.

Tenets of IPD. The IPD philosophy embodies eight key tenets.[12] The F-22 Team used these tenets to guide its implementation of IPD.

(1) Cultural Change: Embracing the IPD philosophy requires purposeful, multi-disciplined teamwork. The priority of focus for IPD should be:

a) The customer
b) The product
c) The process
d) Constraints, ...and then
e) Organizational structure

The first step requires focus on the customers' needs to determine what the product will be. The necessary processes are then implemented in order to deliver the product to the customer. The customer, the nature of the product, and the organization structure provide the constraints applied to the multi-disciplined team. Constraints may require modification to existing processes, development of new processes, and changes to organizational structure.

(2) Product Focus: IPD requires a product focus and a complete understanding of the processes required to optimize the product.

(3) Up-Front Planning: The life cycle of a product or process will be integrated through comprehensive, up-front planning that must include all functions, customers, and suppliers.

(4) Right People, Right Place, Right Time: All functions that impact the achievement of the customer's requirements should be applied concurrently, in a team fashion, throughout the life of a product or process.

(5) Teamwork and Communication: People must function as a team. Team success, facilitated by rapid, open communication, must be emphasized and rewarded. Management relationships must be developed which are consistent with and focused on achieving the team's measurable goals and objectives. Integrated Product Teams (IPTs) are the heart of IPD. The F-22 IPT structure is shown in Figure 1.0. Key characteristics of IPTs are:[13]

a) Team is set up to produce a specific product or service.

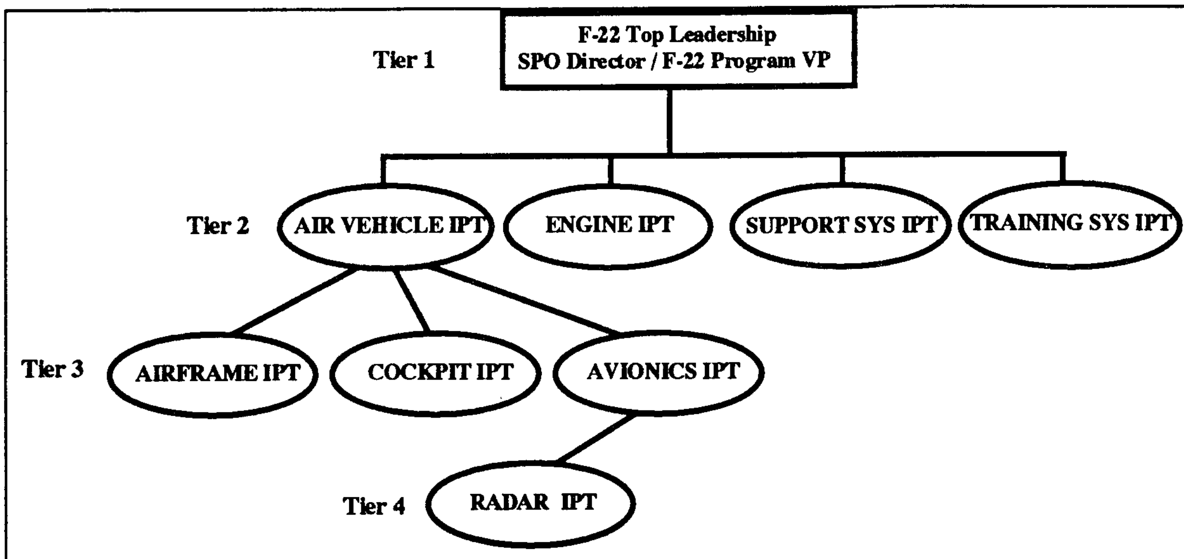

Figure 1.0 - F-22 Team Organizational Structure and Tier Arrangement

b) Multidisciplinary - all team members/functions working together towards a common goal.
c) Members have mutual, as well as individual accountability.
d) Integrated, concurrent decision making.
e) Empowered, within specific product or service goal, to make decisions.
f) Planned integration among teams towards system goal.

(6) Empowerment: Decisions must be driven to the lowest possible level commensurate with risk. Resources should be allocated at levels consistent with authority, responsibility, and ability of the people.

(7) Seamless Management Tools: A framework must be established which relates products and processes at all levels to demonstrate dependency and interrelationships. This hierarchical interrelationship (e.g., Systems Engineering Master Plan methodologies) must be understood and appropriate partnerships established to ensure that all decisions are optimized toward the ultimate user's end product.

(8) Integration Throughout the Life Cycle: IPD will encompass all products and processes, regardless of the point in their life cycle.

7 CHALLENGES to IPD IMPLEMENTATION

Implementation of IPD poses several unique challenges to success. Government and industry leaders have outlined seven barriers to implementing CE concepts (i.e. IPD) within the DoD.[14] These are:

1) Trust
2) Leadership
3) Resistance
4) Resources
5) Contracting
6) Measurement
7) Understanding

The F-22 Team has experienced challenges 1-5 and met them with initial success. Measurement of IPD implementation and fostering widespread understanding of IPD are ongoing efforts.

How the F-22 Team Met Challenges 1-5. During the initial implementation of IPD

within the F-22 Team, challenges 1-5 had to first be overcome. Before any progress towards IPD implementation could even take place, trust had to be established between all F-22 Team members. Trust was established by a long term commitment to making and keeping agreements, maintaining credibility, and maintaining openness. Challenge 2, leadership, was required at all levels of acquisition to support IPD. To provide this, leaders were empowered at the lowest levels possible to make the right decisions. This strengthened team leadership at the worker/action level. Using this method, information is shared and issues are resolved at the lowest practical Integrated Product Team (IPT) level. Challenge 3, resistance by functional groups (i.e., engineering, finance and contracting) was eased by rigorously applying tenet five, teamwork and communication through IPTs. All functions that impacted the achievement of the customer's requirements were applied concurrently in IPTs. Team members take ownership in each action and outcome of the IPT. Early resource commitment, (i.e., time, people, and funding) at adequate levels (Challenge 4) was performed by identifying the requirement for IPD at the beginning of the engineering and manufacturing development phase (EMD). Resources for the IPTs were committed at this time. The F-22 Team overcame challenge 5, contracting, by changing the contract to support IPD and CE concepts. In the initial request for proposal the requirement to implement IPD was first listed in the Statement of Work (SOW). It stated "*...using the Integrated Product Development/Concurrent Engineering approach, the contractor shall accomplish the tasks required to perform systems engineering and program management, and maintain technical control of the F-22 Weapon System.*" This established the use of IPD as a requirement by each contractor.

The Gap - Challenges 6-7. The final challenges to implementing IPD involved fostering universal understanding of the philosophy, processes, tools and applications of IPD and measuring progress of IPD implementation. The AFMC IPD guide provides an evaluation scale to aide measurement and understanding of IPD concepts.[15] The F-22 Team used this scale as a starting point to develop its own understanding and measurement of its IPD implementation progress. After an initial trial with the IPD guide evaluation scale, the F-22 Team found a need to develop their own scale or "tool" which was more product oriented and gave a clearer understanding of what IPD should look like in the organization. The F-22 Team needed to develop a process and tool to measure and improve the implementation of IPD and the overall quality of the F-22 weapon system design. These final challenges were recently taken on by the F-22 Team in the form of the F-22 IPD Implementation Improvement Plan.

THE F-22 IPD IMPLEMENTATION IMPROVEMENT PLAN

A Structured Approach to Measurement & Understanding. With the challenges of measurement and understanding in mind, the SPO Director chartered a project team to develop an assessment tool and a structured process to measure and continuously improve the F-22 Team's implementation of IPD. Eight project team members, chosen to represent the SPO and each of the four primary contractors, developed an IPD Implementation Template (Figure 2.0) as the assessment tool and a process for continuous improvement (Figure 3.0). Key aspects of this process are the use of a

template to assess progress, development of action plans for improvement, and briefings at Program Management Reviews (PMRs)[16] to status progress and facilitate exchange of best practices across the F-22 Team.

Development of the IPD Implementation Template. The structure of the template draws upon the work done by the CALS/Concurrent Engineering Working Group - Electronic Systems Task Group.[17] The template is a matrix, with the rows representing categories and the columns representing stages of implementation. The project team developed the template in two levels for ease of use: a top level template, and a reference level template. The top level template (shown in Figure 2.0) is used as a "quick-look" assessment chart suitable for briefing purposes. The reference level template (Figures 2.1-2.4) breaks down each of the top-level categories into subcategories, providing the detail necessary to perform an assessment. The project team developed wording for the template by gathering inputs and getting feedback from the IPTs. Project team members solicited comments from IPT leaders through personal interviews and a series of trial runs briefed by the IPTs at the August and October PMRs. In their briefings, IPTs were required to brief their assessment, their action plans for improvement, and best practices that could be shared with other IPTs.

CATEGORY	STAGE I	STAGE II	STAGE III	STAGE IV	STAGE N
1.0 Organization Structure	- no interdisciplinary teams - little customer/supplier involvement - decision making distributed through functional organization	- adhoc process action teams (PATs) & tiger teams - decision making resides with person who chartered the team	- integrated engineering design teams - team has authority to make engineering decisions	- multifunction teams - customer/supplier is full team member - decision making authority includes all needed disciplines - team has separate budget, resource authority & responsibility	
2.0 System Integration	- integration & planning handled primarily by upper management	- integration performed serially by function	- system engineering process applied to improve integration	- integration is a principle element of each team 's mission	
3.0 Processes	- processes institutionalized in functional organization structure	- processes becoming team/project oriented	- best practices applied to improve critical processes	- all processes identified, documented and continuously improved	
4.0 Human Resource Management	- HR management functionally oriented	- project teams formed, but HR management still functionally oriented	- HR management processes recognize team needs	- HR management processes fully adapted to team needs	

☒- CURRENT STATUS ☑- DESIRED STATUS

Figure 2.0 Top Level Template - IPD Implementation Improvement Plan

Template Description. The stages of the template (the columns) represent the progressive degrees of implementation of IPD. The wording in each stage describes

what an organization might look like at that stage. In general, Stage I represents an organization that has not yet implemented IPD, while Stage IV represents an organization that has implemented IPD to the fullest extent conceived at this time. The intermediate stages are part of a continuum between the two extremes. Stage N, or Stage Next, represents a stage of implementation yet to be defined. As the IPTs reach Stage IV, they obtain a better understanding of IPD concepts and will begin to look ahead to further improve their IPT. As IPTs increase IPD understanding and strive for continuous improvement, they will begin filling in their own words for Stage N. Once several of the IPTs have defined their own Stage N, the template project team will gather the inputs and publish standard wording for Stage N. This new stage will become Stage V, and another blank Stage N will be added to the right side of the chart. In this way, organizations will always be stretching to find new ways to continuously improve. The empty blocks in the reference level template are areas where the IPTs and project team could not describe intermediate levels of the IPD implementation continuum. These blocks may be filled in later as IPTs use the templates to develop a better understanding of IPD.

The categories of the template (the rows) represent the aspects of IPD the team selected to measure and are aligned with the eight IPD tenets identified earlier. The following is a description of each category of the template.

<u>Category 1.0 - Organization Structure</u>: IPD tenet 4 states that "All functions that impact the achievement of the customer's requirements should be applied concurrently, in a team fashion, throughout the life of a product or process." Organization structure is often the first, and most recognizable, change made to implement IPD. IPD represents a shift in the project management approach from functional orientation to product orientation. Therefore, creating the proper team environment for IPD implementation is imperative. The very essence of IPD is that all necessary disciplines are represented on the team, so that their inputs can be made to the product. In general, IPTs are the predominant organization structure used to implement IPD. The IPT is simply a team of the right people. This category examines the composition of the team, involvement of customers and suppliers, and the interaction of the team members. Empowerment, another IPD tenet, is also measured by assessing the team's scope of accountability, authority, and responsibility.

<u>Category 2.0 - System Integration</u>: Based on F-22 experience, one of the biggest challenges of IPD is integration across IPTs. While IPTs are focused on delivering their product, careful attention must be paid to integrating across teams so that decisions are made to optimize the final product for the end-user. Integration and planning methods must be developed and applied across the teams to achieve final product optimization . In addition, the program office must have a clear set of customer requirements, as well as a process for capturing evolving requirements, to understand what the end-user needs. By examining the planning methods and processes used to accomplish effective requirements definition and integration, this category assesses the tenets of Up-Front Planning, Integration Throughout the Life-Cycle, and Seamless Management Tools.

Category	STAGE I	STAGE II	STAGE III	STAGE IV	STAGE N
1.1 Team Composition - who is on the team	- task distributed to functional organizations	-problems/special initiatives lead to creation of ad hoc teams staffed by functional experts	- dedicated design team composed for duration of project	- dedicated comprehensive team composed for life-cycle (engr, mfg, QA, logistics, business mgt, etc.) - skill mix evolves with program phase	
1.2 Team Member Interaction - how team member's work together	- individuals focused on specific task or discipline within their functional organization - tendency to sub optimize to strongest discipline		- multi discipline perspective (aerodynamics, structure, avionics, controls, etc.)	- multi-functional perspective (Eng., logistics, mfg., business mgt., etc.)	
1.3 Decision making- scope of accountability, authority and responsibility	- management plays directive role - short term focus/payback dominates	- management delegates decision making to ad hoc team for specific problem resolution/initiative	- team has authority to make engineering decisions	- management clearly defines team decision boundaries, authority, & accountability - team has separate budget, resource authority & responsibility	
1.4 Customer/ Supplier (C/S) Involvement - customer includes internal, external, and end users (ACC, ALC, operational units etc.) Suppliers include internal and external.	- c/s involvement limited to formal reviews		- team actively solicits c/s inputs	- c/s is active team member, participates in team decisions	

Figure 2.1 Reference Level Template - Category 1.0 "Organization Structure"

Category 3.0 - Processes: IPD tenet 2 states, "IPD requires a product focus and a complete understanding of the processes required to optimize the product." While IPTs focus on the product, process management is essential to the effective operation of the IPTs. The functional organizations play the key role as "process owners" in establishing, maintaining, and improving processes used by the product teams. Effective process management helps mitigate the impact of personnel turnover and aids in consistent integration across the IPTs. As identified by IPD Tenet 5, communication is essential to the success of IPD. Information must be exchanged horizontally and vertically throughout the organization to ensure effective integration across the IPTs. This category examines key organizational processes and the methods used to improve these processes.

Category 4.0 - Human Resource Management: As indicated by IPD tenet 5, for IPD to succeed "Management relationships must be developed which are consistent with and focused on achieving the team's measurable goals and objectives."

Category	*STAGE I*	*STAGE II*	*STAGE III*	*STAGE IV*	*STAGE N*
2.1 Integration - How integration occurs.	- product integration by a few project engineers		- small team of systems engineers facilitate integration process - team responsible for integration	- integration processes defined and used - teams accountable for interface mgt.	
2.2 Plan/ Methodology - process used to plan & monitor the program (short term)	- planning expressed as individual detailed tasks and the project plan is the collection of these detailed tasks	- an aligned view of the project achieved through work breakdown structure methodologies	- tasks are concurrent & interdependent - interrelationship between tasks must be known and planned accordingly	- task identification iteratively improved throughout development	
2.3 Program Master Plan (PMP) - organization's planning (long term) to address future program path and potential issues (e.g., technology transition, P3I)	- no documented long term plans	- PMP exists but sits on the shelf	- long term planning documented by management but not flowed down	- PMP is working/living document, strategic outlook - guides teams product/tactical decisions to lowest levels - 3 to 10 plus year outlook as appropriate for product	
2.4 Requirements Definition - process for capturing customer requirements and translating them into the product/process specification to satisfy complete life cycle needs	- customer defines requirements to every supplier (e.g., ACC to SPO, SPO to Ktr, Ktr to vendor)		- requirements challenges are encouraged by the customer as the design matures	- joint, iterative, requirements definition through all customer/ supplier (c/s) relationships (e.g., ACC, SPO, Ktr, vendor)	
	- design flexibility is limited by detailed requirements definition		- aware of new / changing requirement however, reactive response incurs cost & schedule impacts	- anticipating change and responding effectively to new requirements with minimum cost & schedule impact due to strategic outlook	
	- requirements may not be fully understood by designers	- requirements understood and accepted by designers			
	- requirements introduced before adequate maturity resulting in excessive scrap & rework			- adequate time provided up front before design release to mature all requirements	
	- requirements traceability tools not used	- derived requirements not traceable to higher specification	- requirements linked across specifications	- upward/downward traceability database supports validation/ verification	

Figure 2.2 Reference Level Template - Category 2.0 "System Integration"

Category	*STAGE I*	*STAGE II*	*STAGE III*	*STAGE IV*	*STAGE N*
3.1 Communication - information exchanged between and within organization components	- up and down functional chain - information received is functional specific, lack information outside the functional discipline	- functional lines of communication blurred, no communication norms established - ad hoc team gathers information to complete their project, communication outside the ad hoc team suffers	- communication within teams but limited between teams, communication norms established - some incomplete and untimely information, junk mail impedes processing of relevant information	- information is exchanged horizontally & vertically throughout the organizations - everyone receives all the information they require when it is needed, no junk mail	
3.2 Reviews - process for assessing product process	- schedule-driven process and product critiques - each discipline schedules series of reviews with little consideration of cross-discipline trade-offs	- event driven reviews ensure complete design package, rather than pieces, is reviewed - reviews are multi-disciplined with total team participation	- immediate issue resolution - process in place to gather real time input to make decisions versus waiting for a formal review	- non-interruptive internal status reviews (ISRs) used to ensure correct processes are observed - ISRs develop strategies for product & process improvement rather than focusing on the details of the design	
3.3 Information Resource Mgt. - process for timely exchange of accurate information which efficiently utilizes communication/ computing technology	- local individual data management - data requested as needed from other disciplines - few data management tools	- data is managed by the multi-discipline team - data is structured for sharing within the team - tools are in place for team members to retrieve the data they need to make optimum tradeoffs	- data is automatically provided to users that need the information - smart tool in place for data generator to automatically communicate information to impacted team members	- repository of working data available across entire team enterprise - appropriate data management system in place with efficient and accurate interpretation of queries	
3.4 Tool Development & Usage - management tools (e.g., cost, schedule, performance) - technical tools (e.g., design & analysis)	- Minimum usage of standard tools	- Some usage of automated tools	- Automated tools developed for critical processes	- Initiate integration of tools across teams	

Figure 2.3 Reference Level Template - Category 3.0 "Processes"

There is a clear recognition that Human Resource Management must evolve to facilitate IPD. However, Human Resource Management is typically the last function to change practices to meet the needs of IPD due to the difficulty of changing personnel systems. In creating the subcategories, the project team chose aspects of human resource management that must change to facilitate operations in the IPD environment.

Key Concepts to Understand about the Template. There are several key concepts to understand about the development of the Template and its use.

1) The template was purposely developed to be subjective, rather than objective. The project team felt there would be more openness and honesty in the assessments if

scores were not attached to the template. This reinforces the SPO/Contractor team relationship as well. Despite the F-22 Team's history of close SPO/Contractor relationships, there continues to be a concern on the part of the contractors that this assessment will be used as a "hammer" by the SPO. In addition, we made assurances that results would not be used as an Award Fee criteria.[18] To further dispel contractor concerns and in keeping with the F-22 teaming philosophy, assessments are conducted across companies and the SPO. For example, the Airframe team consists of sub-IPTs from the F-22 Systems Program Office (SPO), Lockheed Aeronautical Systems Co. (LASC), Lockheed Fortworth Co. (LFWC) and Boeing Military Airplanes Division (BMA); therefore, the assessment takes all 4 sites into consideration. The Airframe IPT co-leads at the SPO and contractors develop their assessments together and brief them together at PMRs. In this regard, it is truly a team assessment.

2) The wording of the template was chosen to be applicable at any of the contractors/ SPO and at any level of the F-22 Team. Therefore, the wording is necessarily general and not specific to the government. It represents a "best fit" between four diverse contractors and the SPO, and all the tiers of management within each. Some categories and descriptions will be more applicable to individual organizations than others. The wording is meant to be used as a guide for further discussions within and between IPTs. Users of the template should

Category	*STAGE I*	*STAGE II*	*STAGE III*	*STAGE IV*	*STAGE N*
3.5 Bench marking - search for best practices leading to superior performance	- internal company lessons learned used to improve processes	- knowledge of other companies; best practices is increased and used to improve processes	- industry best practices used as benchmarks for improvement of processes - most processes have benchmarks to strive for	- systematic approach for continuous improvement through competitors / like processes (e.g., process cycle time, defects per unit measure)	
3.6 Metrics Development & Usage - use of metrics to achieve continuous improvement	- not enough of the right metrics - too many of the wrong metrics	- just collecting metric data	- metrics used to control some processes	- metrics data drives improvements	
3.7 Risk Management - how risks are identified and mitigated	- ad hoc process for identifying some risks	- systematic approach in identifying risks	- business management & systems eng. mgt. develop an approach to identify and mitigate risks	- teams identify and mitigate risks at lowest level	
3.8 Customer Satisfaction Feedback - process for obtaining and using customer feedback to improve processes & products (customer is any party that receives the result of a process)	- no customer feedback solicited - individual disciplines optimize their areas using prior experience	- ad hoc customer feedback solicited - limited use of feedback	- systematic feedback process in place - feedback on difficult improvement areas ignored	- IPTs establish channels to continuously gather feedback - feedback used by IPTs to improve processes/product	

Figure 2.3 Reference Level Template - Category 3.0 "Processes" (Cont.)

not focus on the specific wording, but use it as a framework and tailor it for their own applications.

3) The assessments should not be "rolled up" or averaged from the reference level template to the top level template. Similarly, the results from lower tiers should not be averaged to assess a higher tier.

4) It is generally assumed that farther to the right on the template is better. However, there may be cases where, an organization does not want to progress further to the right, given the complexity of the project and/or the resources available. For example, a team with a relatively simple task may not need the most advanced methods of systems integration. To implement them may be too costly or time consuming for the task at hand. The team could assess themselves at Stage II or III and, looking ahead, decide they have progressed as far as is

Category	*STAGE I*	*STAGE II*	*STAGE III*	*STAGE IV*	*STAGE N*
4.1 Resource Allocation - process for distribution of human resources	- resources tied to specific disciplines rather than products	- top level management allocates human resources based on product development needs	- resources allocated to the teams by functional organizations - team leader communicates human resource requirements to functionals	- team members assess resource needs and identify and select members - functionals provide motivated, skilled, trained resources as candidates	
4.2 Training and Education - training teaches the how of the job. Education teaches the why of the job - functionals nurture & broaden individual disciplines	- training emphasis on specialties/functional skills	- group dynamics and conflict management included in curriculum	- team training initiated, whole teams are trained as a unit - cross functional specialty awareness education	- training and education based on formal group assessment of team performance - training & education are tailored to meet team needs	
4.3 Recognition - basis for awards/recognition	- limited individual awards based on functional knowledge - members want individual awards	- individual awards - management rewards "Lone Ranger" heroes for solving short term crises	- team allocates award to individuals - "Hero" status is team-determined - award based on contribution to team goals/objectives	- team award based on contributions to long term program goals, not for short term sub optimization - "Heroes" not rewarded if team fails - members demand team awards versus individuals	
4.4 Performance Appraisals - how project members are rated and by who	- members rated by functional chief based on individual functional performance	- members rated by functional chief based on individual performance on team	- team leaders rate member on team performance - functionals rate member on discipline expertise	- team member inputs considered in performance appraisal	
4.5 Leadership - who leads the team and how the team is led	- centralized, functional lines control activities - management appoints leader	- management-selected interdisciplinary team leader	- team selected interdisciplinary leader	- formal interdisciplinary leader with subject matter leaders emerging based on ability & knowledge required for specific task - all team members accept accountability for team performance	

Figure 2.4 Reference Level Template - Category 4.0 "Human Resource Management"

economically practical. In this case the template is also valuable: it has given the team a method to assess their current state, evaluate possible "next steps" that could be taken, and make a conscious decision to remain in their current state. The team will not waste resources pursuing improvement just for improvement sake. However, most teams using the template will find improvements, no matter how small, that can be made to increase their effectiveness.

5) There should be no stigma attached to assessments at lower stages. This is simply an indication of the maturity level of IPD within the organization and the distance yet to travel. The focus should be on making systematic evaluations and developing action plans for improvement. It is also important to realize that teams may move to a lower stage of the template over time due to changing program conditions, changes in personnel, or implementation of new policies/processes.

The F-22 Team IPD Implementation Improvement Process. As important as the template itself is the process developed to drive continuous improvement of IPD implementation. Following the PMR trial runs, the project team revised the template and refined the implementation process. In developing this process, the project team considered these factors:

(1) To optimize time spent by the IPTs, the process should dovetail with normal operations of the F-22 Team and there should not be separate reviews

(2) The process should compliment the F-22 Team Plan[19] (i.e., strategic planning) process

(3) The process should emphasize improvement as well as assessment

The team briefed its recommendations for changes and further use of the template at the November 1994 F-22 Team Executive Offsite (the annual strategic planning meeting of senior leaders from across the F-22 Team). The offsite participants accepted the recommendations of the project team to continue use of the template through 1995. As shown in Figure 3.0, the process consists of the following elements:

Annual IPT Assessment: Each Tier I, II and limited Tier III IPTs use the template to perform an annual assessment. The assessment takes place in September or October, timed so that the IPTs can develop action plans to work for the coming year, and identify program-wide IPD issues for the F-22 Executive Offsite. The IPTs assess their current status on the template and their desired (goal) status. At the same time, they identify obstacles that are out of their control that block their progression to the next stage. These obstacles are raised as issues to the next higher tier and, eventually, to the Executive Offsite for resolution.

Developing Action Plans: The IPTs develop action plans to help move them further along toward full IPD implementation. Action Plans consist of the action needed, the responsible individuals, the planned completion dates, and any interim milestones.

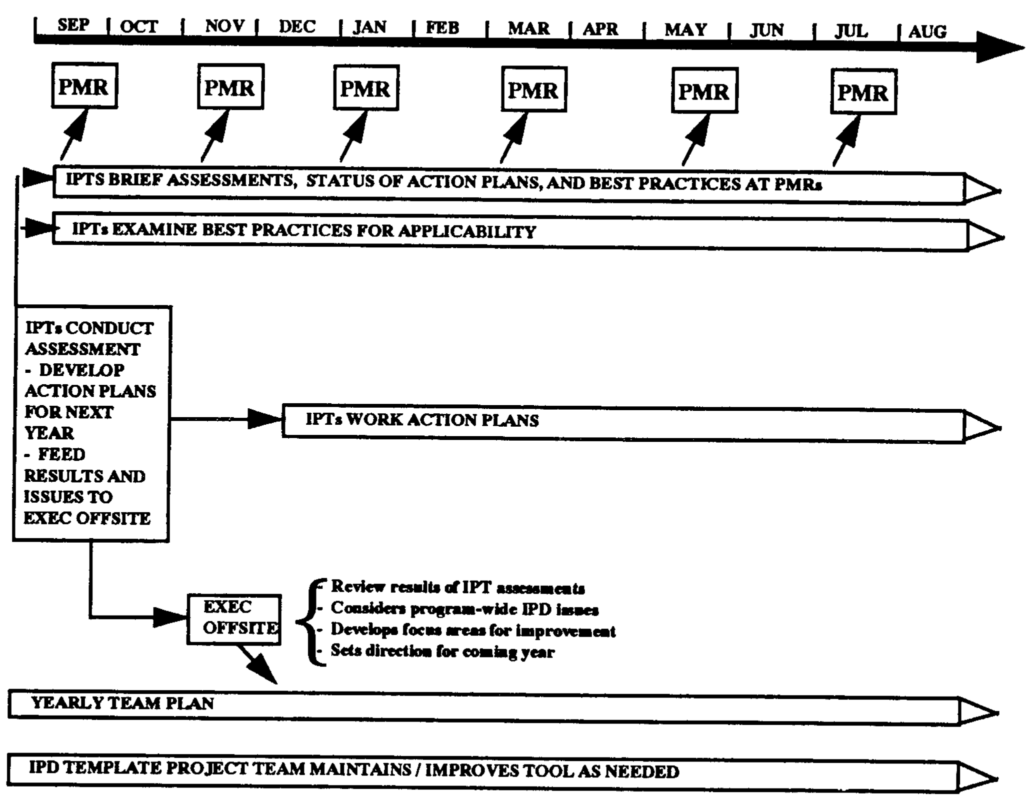

Figure 3.0 - F-22 IPD Implementation Improvement Process

Sharing Best Practices: To help the flow of information across IPTs, each IPT identifies and briefs "Best Practices" (i.e., good ideas, innovative processes, or management techniques that may be applicable to other IPTs).

Status Progress Reports: IPTs brief their assessments and Action Plan status at Program Management Reviews which are held every 8 weeks.

Template Maintenance: The template project team maintains and updates the template as needed throughout the year based on the development of new stages by the IPTs. In addition, the project team maintains a database of Best Practices presented by the IPTs at the PMRs.

Results to Date. The past three years of IPD implementation on the F-22 Team and the first iteration of the IPD Implementation Improvement Plan have produced the following lessons learned from the IPTs across the F-22 Team:

o Understand who all your customers are. Active customer involvement is essential. Traditional roles must change.

o Top level leadership (tier 1) on the part of both government and contractor must visibly commit to an IPD continuous improvement plan for it to work.

o IPT training is essential at all levels (Company/command, program, and IPT member levels).

o Management cultural changes do not occur overnight - functionals tend to resist IPT arrangements. IPT leaders must have

authority over personnel and budget resources.

o IPTs must have experienced and empowered members to fully represent their functional discipline (e.g., engineering, finance, etc.). Otherwise the product will suffer in that functional discipline.

o The "I" in IPT can easily become "Independent" vice "Integrated". Integration across the IPTs at every level is absolutely imperative.

o IPT members should sit together. IPTs dispersed at various sites should meet on a periodic basis . An integrated network of software tools is extremely useful to improve communication between dispersed IPTs.

o Set team goals/objectives - and track them! Ensure all team members participate in decisions. Develop meaningful team metrics.

o Put the right people in the right job at the right time. Appoint and train "LEADERS". Replace leaders that don't/can't lead.

o IPTs are wary of criticism by top leadership as they use the template and identify improvement areas. IPTs need the opportunity to improve.

o IPTs were convinced of the usefulness of the IPD Implementation Improvement Plan. It provided a structured review of IPT effectiveness and identified possible areas of improvement.

SUMMARY

The F-22 Team will continue to use the IPD Implementation Improvement Plan as they work Action Plans, identify Best Practices and perform another IPT assessment in the Fall of 1995. Linkage of the plan to the F-22 Team (Strategic) Plan provides a natural cycle for review and replan as necessary at the annual Executive Offsites. Only through a systematic approach of measurement and planning such as this can the primary goal of meeting the F-22's mission be achieved.

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[1]The F-22 Team members are identified as Air Combat Command, the F-22 System Program Office, Lockheed Aeronautical Systems Co. (LASC), and their team members Lockheed Fort Worth Co.(LFWC) and Boeing Co., Pratt & Whitney Co., 26 major subcontractors, and other government agencies including HQ USAF, Defense Plant Representative Offices (DPRO), and Office of the Secretary of Defense (OSD), etc.

[2]President's Blue Ribbon Commission on Defense Management. A Quest for Excellence, Final Report to the President by the President's Blue Ribbon Commission on Defense Management, June 1986. Washington: GPO, 1986., p. xxii.

[3]Institute for Defense Analyses. Role of Concurrent Engineering in Weapons System Acquisition. IDA Report R-338, Washington: GPO, December 1988, p. v.

[4]Institute for Defense Analyses. Role of Concurrent Engineering in Weapons System Acquisition. IDA Report R-338, Washington: GPO, December 1988, p. v.

[5]Womack, James P. and others. The Machine that Changed the World - The Story of Lean Production. New York: Macmillan Publishing Company, 1990, p. 116.

[6]Institute for Defense Analyses. Role of Concurrent Engineering in Weapons System Acquisition. IDA Report R-338, Washington: GPO, December 1988, p. v.

[7]Institute for Defense Analyses. Role of Concurrent Engineering in Weapons System Acquisition. IDA Report R-338, Washington: GPO, December 1988, p. vii.

[8]OSD/USD(A). Memorandum for Secretaries of the Military Departments, Subject: Concurrent Engineering--A Total Quality Management Process. Washington DC, 9 March 1989.

[9]SAF/A(A). Memorandum for AF Acquisition Policy on Concurrent Engineering: A Total Quality Management Process - ACTION MEMORANDUM. Washington DC, 2 February 1990.

[10]Since then, AFSC has merged with Air Force Logistics Command (AFLC) into what is now the Air Force Materiel Command (AFMC).

[11]AFMC Pamphlet 800-60 Integrated Weapon System Management Implementation Guide, Reference Attachment E. "Integrated Product Development Guide", 31 March 1993, p. 275

[12]AFMC Pamphlet 800-60 Integrated Weapon System Management Implementation Guide, Reference Attachment E. "Integrated Product Development Guide", 31 March 1993., p. 275

[13]AFMC Pamphlet 800-60 Integrated Weapon System Management Implementation Guide, Reference Attachment E. "Integrated Product Development Guide", 31 March 1993., p. 289

[14]Report on the DoD Workshop on Concurrent Engineering, Defense Systems Management College, November 14-15, 1990; December 17-21, 1990; and January 28-29, 1991.

[15]AFMC Pamphlet 800-60 Integrated Weapon System Management Implementation Guide, Reference Attachment E. "Integrated Product Development Guide", 31 March 1993., p. 301

[16]PMRs are bimonthly program status reviews used by the F-22 senior leadership to status the health of the program.

[17]First Principles of Concurrent Engineering - A Competitive Strategy for Product Development, CALS/Concurrent Engineering Working Group-Electronic Systems, 12 May 1992.

[18]The F-22 Contract is a cost-plus Award Fee Contract. An Award Fee is paid to the contractors every six months based on a subjective evaluation of their performance by the SPO. The Award Fee criteria are written and agreed upon by the SPO and the contractors every six months and form the basis of the evaluation.

[19]In a concurrent effort during 1994, the F-22 Team developed its initial Team Plan, the strategic plan for the F-22 Team. This plan identifies the F-22 Team's vision, mission, and goals, and establishes focus areas to be worked over the next year. Participants at the November 1994 F-22 Team Executive Offsite ratified the Team Plan and determined the focus areas, by priority, that the team would work through 1995. Goal 5 of the Team Plan is "Enhance IPD through Continuous Improvement to Assure Final Products Meet Customer Requirements." The IPD Implementation Improvement Process is one of the methods for reaching this goal and for measuring progress.

TAKING THE NEXT STEP: IMPLEMENTING ORGANIZATIONAL CHANGE

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There is nothing more difficult to take in hand, more perilous to conduct, or more uncertain in its success than to take the lead in the introduction of a new order of things.

Niccolo Machiavelli [1]

ABSTRACT

To survive in today's highly competitive operating environment, organizations must learn how to effectively implement change. Historically, this has proven difficult, particularly in bureaucratic organizations like DOD. Our natural tendency is to focus on analysis and prescription, rather than to tackle the tougher challenges of "implementation." This article addresses those challenges, their underlying causes, and offers some thoughts and ideas for consideration and use throughout the entire change process.

INTRODUCTION

When the Federal Acquisition Streamlining Act of 1994 was signed into law this past October, it was widely hailed as one of the most important steps the nation could take toward reforming defense acquisition and meeting our long-term strategic economic and policy objectives. Lengthy detailed military specifications and acquisition procedures will now give way to broader performance based standards, best commercial practices, and electronic commerce, along with the promise of an expanded supplier base and hundreds of millions in annual savings. After years of delays, false starts, and numerous "Blue Ribbon" studies, procurement reform appears to have finally come to the Pentagon. Or has it?

Intuitively we have our doubts. We know from experience that simply passing new laws and shipping copies to the field, does not guarantee a new order, but merely signals the beginning of the more difficult and elusive task of implementing organizational change. Change that can occur only through effective and determined leadership, clear strategic vision and goals, and the successful management and execution of well thought out

implementation plans. Change which moves us beyond fuzzy top level guidance written in law and toward a more specific series of actionable steps tied directly to organizational processes, individual responsibility, and measurable results centered success criteria.

ORGANIZATIONS - A WAY OF LIFE

Organizational reform movements are certainly not new. Ambitious efforts to enhance everything from manufacturing processes to internal communications have been tried, and continue to be commonplace. Historically, however, organizational change has proven a tough sell, with most reform efforts falling far short, often contributing little or nothing to bottom-line performance.[2] We shouldn't be surprised. Change competes with our natural preferences for stability and control. Collectively whether we work in government or industry we reside in organizations out of necessity, protective structures that evolve over time in response to personal needs, cultural biases, and group norms. "We are born, raised, and educated in organizations. We work in them and rely on them for goods and services. Many of us will grow old and die in organizations. We have built so many organizations because of what they can do for us."[3]

Ironically, even though the proliferation of complex organizations has made almost every human activity a collective one, we instinctively resent the forces that manage and control them.[4] More of us than ever are unwilling to subject ourselves to an organization or the discipline of a trade, profession, or team.[5] This love-hate relationship with the organizations governing our lives highlights the virtues and drawbacks of coordinated activities, the wide chasm between managerial intent and organizational accomplishment, and the human element that must embrace change in order for "implementation" to succeed.[6]

TOWARD IMPLEMENTATION

"Successful fundamental change [has] three components: the analytic component (focusing on the deficiencies to be corrected), the prescriptive component (setting forth the objectives of the change and its general characteristics), and the strategic component (dealing with the strategy and tactics for the process of change)."[7] All of us are familiar with the first two: diagnosis and prescription. In fact it is difficult to imagine not being able to find someone in government or industry with an opinion on how to improve current operations. Unfortunately recognizing problems and offering suggestions is the easy part. The change process gets significantly more difficult when a strategy and action plan for "implementation" are required.

DOD's acquisition system is a classic case in point. For over twenty years high-level commissions have offered analysis and prescriptions for defense procurement reform, however, we consistently have been unable to take the next step forward toward implementing change.[8] Our downfall has been an inability to formulate the concrete measures necessary for putting recommendations into practice or to translate new ideas into specific actionable steps that could be carried out.[9] Although some may argue policy limitations make substantial change all but impossible, DOD's situation is not unique. All large organizations encounter a like set of personal, professional, and political constraints as they move through the change process. Congressional inquiries, labor disputes, shareholder demands, and government regulations, along

with competitive market forces all combine to make commercial sector reform efforts equally difficult. And ultimately, every organization once it completes the analytic and prescriptive phases of the change process faces the same chronic dilemma, the successful development, management and execution of the strategic and tactical components of change, well thought out implementation plans.

CULTURE WARS

Lack of a well defined or well executed implementation plan is not an unusual situation, nor is it confined only to government operations. "Many [corporate] strategic plans die because of lack of implementation. There is a high correlation between the failure to implement changes and the lack of conscious management of the transitional process."[10] Clearly, implementing actionable change at any level within an organization is not easy. Change challenges our sense of normalcy, bringing fear, uncertainty, and loss. "Ask...people why change is hard, and sooner or later - usually sooner - you'll hear the word "culture." Changing corporate culture, that's murder. It will rise up and smite you."[11] This is particularly true when you're breaking new ground. "By definition you have different values from your management - both the people you work for and those who work with you. The risk of failure is great. Snipers and cynics may be waiting anywhere - higher up in the company, among peers, among subordinates."[12]

We shouldn't be surprised by institutional resistance. As a workforce, we have been culturally programmed to avoid failure, risk, and confrontation, to conform to established procedures, and to operate within clearly drawn lines of authority and responsibility. Venturing outside the "white lines" to implement change is especially difficult, particularly if we must give up power or control over our own lives to do so. And nowhere is change avoidance more evident than in today's highly charged operating environment. Explosive political, economic, technological, and societal forces are driving dramatic service realignments, mission expansion, base closure decisions, and civilian workforce downsizing. Accepting change or giving up control may now mean losing your job. The personal stakes are high.

Even senior acquisition leaders who have lead past procurement reform efforts and have always shown great affinity and enthusiasm for diagnosis and change, in practice find it too difficult to focus on "implementation." Instead they preferred drifting back toward a continuing analysis of what is wrong with the current system.[13] Perhaps this explains our natural inclination for studying problems vice solving them. And while it is easier to allow our known cultural and organizational biases to protect us then to deal with them head-on, understanding both the positive and negative role they play in human and organizational behavior patterns is key to effectively dealing with the broader challenges of implementing change.

SETTING THE COURSE

Although corporate culture remains both an obstacle and asset to be managed, true organizational change can only be successful if it is actively supported, well communicated, and fully understood by top management. Top management must be committed and lead. Senior leadership's broad perspective and corporate view, authority to cross functional boundaries, and power to motivate employees beyond marginal gains is critical to success.[14] This

is not to say employees should not be a large part of the change process or that they can not be a source of great ideas and magnificent support. On the contrary, it is to emphasize that significant organizational change comes from engaged leaders with well defined agendas and clear corporate visions for the future. "There is no more powerful engine driving an organization toward excellence and long-range success than an attractive, worthwhile, and achievable vision of the future, widely shared."[15]

Beyond setting a vision, however, effective leaders must also show the way. Followers want their leaders to take them on increasingly inspirational journeys and in fact judge them on their ability to set the course and steer them toward it.[16] Failure by management to take-on this role or assumptions the latest gimmick can solve all problems, encourages defeat and leaves an organization groping for direction. "One [sure] sign that a company is Clueless in Seattle, or wherever, is [when] top management starts succumbing to management fads...and [after] several rounds of reengineering...[t]he work force can become jaded in the process and suffer what Peter Scott-Morgan...calls *change fatigue*. The eventual result is often widespread worker resistance to new initiatives, which frustrates management further and can spiral into ever more draconian, equally unsuccessful efforts to motivate the troops."[17]

Escaping from this often self-imposed death spiral, however, is difficult until we know ourselves. Usually we don't. We demonstrate a "great reluctance [for] recogniz[ing] just how fundamentally flawed many [of our] organizations are. This is a splendid example of what sociologists call *pluralistic ignorance*. Everyone is aware of the same thing, but because people think it true only for themselves, all pretend otherwise. Refusal to face the deep flaws at the core of organizations deflects attention from the real problems to the symptoms."[18] Moving beyond merely treating symptoms requires visionary leadership, both of what is possible and what is desirable. There is no mystery here. Leaders are the catalysts. Their sense of urgency and campaign for change focuses the agenda, breaks the status quo, maximizes employee involvement, and begins the real work of organizational transformation.

SHARPENING THE FOCUS

Taking the next steps, however, requires a significant shift in organizational focus. Today much of the work done in large organizations exists solely to support internal operations rather than to deliver goods and services to meet customer's needs. Bloated bureaucratic layers attest to management excesses "...with each layer having an opportunity to reject, deny, modify, filter, eliminate, reduce, stretch, or otherwise retard every suggestion that has the audacity to seek to wind its way through the labyrinth-like approval process adopted by most large organizations."[19] Moving beyond these bureaucratic "activity centered" programs and toward "results driven" processes that contribute directly to our organization's bottomline must be our objective.[20] For too long we have defined success not by how well we have met or exceeded our customers definition of quality, but by whether we answer the day-to-day demands our organizations have imposed on us. And sadly, we have been subtlety indoctrinated into an organizational mindset which equates 100% attendance at quality training courses with success and suggestions that any attempt at implementing change must be slow and painful.[21]

Breaking this mindset and sharpening our focus on results driven improvements can be a powerful tool for implementing lasting change. By identifying critical areas where improvements are urgently needed and then ensuring those who study and recommend solutions are also held accountable for producing measurable results in a methodical step-by-step fashion, dynamic change will occur and productivity will increase. Employees need to experience both the responsibility and success that come from the results of their work. Success breeds confidence, hones skills necessary for continued gains, and provides a learning environment for teaching employees to deal effectively with the competing needs of all involved. This methodology of tying individual responsibility to actionable steps and specific results challenges our conventional bureaucratic approach to problem solving, reinforces, energizes and rewards performance, forces a fundamental shift in organizational focus, and places increased discipline and thoughtfulness into the entire corporate planning process.

STRATEGIC PLANNING

Strategic planing is perhaps the most basic of all corporate leadership functions and the primary building block for successfully implementing change. During the change process, good planning encompasses a wide range of functions, including everything from setting a strategic focus, establishing organizational goals, and allocating resources, to defining success criteria, scheduling timelines, and determining individual responsibilities. Flexibility is critical, as each area is highly dependant on the other and each contributes to the overall success or failure of the planning effort.

Too often, however, the planning process breaks down. In our zeal to tackle change, our implementation plans are not well thought out and are typically managed through the normal operational hierarchy rather than through a dedicated change management resource.[22] As a result, communication suffers, momentum is lost, and change stalls. A dedicated change agent, a well defined implementation plan, and a correctly aligned organizational support structure can eliminate these problems, while acting as a facilitator and conduit for feedback by providing avenues for timely action and quick responses to problems or questions as they arise. They also help the organization institutionalize change. "It has long been recognized that organizations have great power to shape behavior, not so much by forcing it as by encouraging it. Organizations make some things easier and some things harder, thus making the former more likely and the later less likely. This is the work not simply of *culture* - something in people's heads - but rather the formal aspects of the organization, such as its distribution of roles and responsibilities, people's authority to commit resources, existing budgets procedures, the physical or geographical arrangement of its space and facilities, differences in information access and availability, and reward and recognition systems."[23] Fully integrated organizations and dedicated planning processes build trust, teamwork, cohesion, and accountability, while further encouraging the continuous shift in human behavior being brought on by organizational change.

LETTING GO

While good organizational planning arrangements can make or break any implementation effort, true success is usually tied to a managers ability to let go. "The introduction of a new order often requires a dramatic shift in leadership style and a

loosening of the reins of control, as decision making is moved closer to those who deal with customers."[24] Decentralization does not mean that organizations must approach anarchy, even though managers may fear any change to the status quo threatens their level of power, authority, and influence within an organization.[25] On the contrary, it encourages ownership, reduces risk, and works to lessen "...the even greater danger that errors will be made by decision makers both unfamiliar with the details and having insufficient time for careful consideration of the implications of detailed decisions."[26]

"Our present policy seems to be aimed primarily at not letting anything go wrong - but [often has] the unintended consequence of precluding us from letting anything go right. Lamennais's apothegm applies: *Centralization breeds apoplexy at the middle and anemia at the extremities.* The key to effective management of the defense acquisition process is really very simple: employ capable people, establish clear goals, monitor results, and get out of the way."[27] You can expect that once this occurs, organizations will move closer to their customers, communication will improve, and employees will understand the impact of their actions and be able to respond to customer needs faster and more perceptively.[28] The end result is employees become more productive, take on more responsibility, and typically become willing partners for implementing change.

CREATING VALUE

As partners throughout the change process, it is also important employees feel they will be well trained, empowered, and have a voice. Open communication channels, active organizational involvement, and continuous training programs certainly help, but management commitment to their needs is critical. "One of the fundamental problems in organizations, including families, is that people are not committed to the determinations of other people for their lives. They simply don't buy in."[29] "Without involvement, there is no commitment. Mark it down, asterisk it, circle it, underline it. No involvement, no commitment."[30]

Building employee commitment requires most organizations to rethink their training methods and learning processes. "[V]ery few organizations have a conscious strategy to implement [change] in a learning mode. Normally, change is measured only in terms of results; rarely is there any measure of the process of improvement."[31] Through the establishment of measurable success criteria, process flows, and individual "data" ownership, loyalty can be built. Even the best people will produce poor results if they are not trained to understand how their actions influence corporate performance. And the potential for performance improvements is unlimited since we know that "...people genuinely strive to produce what they intend. They value acting competently. Their self-esteem is intimately tied up with behaving consistently and performing effectively. Companies can use these universal human tendencies to teach people how to reason in a new way - in effect, to change the master programs in their heads and thus reshape their behavior."[32] Ultimately, well trained and educated employees represent the most basic element for ensuring the viability and success of organizations, and their long term value becomes even more important as "...[b]reakthroughs in technology continue to enhance [our] efforts to dismantle the traditional, hierarchical corporate structure and to realize the potential of a networked, nimble, customer-responsive organization."[33]

CLOSING THE LOOP

Responding to customer needs is clearly the number one reason why organizations change or consider change. Strategic vision, senior leadership, corporate planning, employee empowerment, and individual training all play active roles in supporting the implementation process, but each is highly dependant upon open communication, continuous performance feedback, and measurable results for determining whether change is successful. Successful organizations value feedback from any source or in any form. Without it, they can not function or survive. Every employee actively communicating provides an insight and perspective necessary to set and run operations, collect data, adjust systems, correct mistakes, and keep customers informed. This is especially true now in our information society where for the first time in civilization the name of the game is people interacting with other people.[34]

This is particularly true in a service organization like DOD, where "...internal communication among employees is often more important than the more visible external communication with customers."[35] Clear communication of job expectations, joint goal setting, and measurement and appraisal of results help define employee performance and the value of their productivity. It also helps to close-the- loop on the overall problem-solving process by evaluating results.[36] "The importance of [a] closed-loop approach to solving problems becomes evident when you recognize that circumstances change, situations change, people change, and your preferences and values change. You must adapt your solutions to the changing times, and this means occasionally rethinking the solution entirely."[37] Constant reevaluation of the entire organizational change process and a continuous reminder that what is most important about any event is not what happened, but what it means must be our standard operating approach.[38] By collecting valid data, analyzing it carefully, and constantly testing the inferences drawn from it; we can identify not only those activities which add the most value and improve our ability to distinguish between routine and creative tasks, but we can see the historical results of our entire change process and seek ways to improve it.[39]

LOOKING FORWARD

As DOD approaches the next century, we will continue to be buffeted and shaped by many powerful forces. How well we respond, and how well we implement change will dictate whether we can break from the past and move forward. Over the years we have become victims of our own success, trapped by earlier achievements. Unfortunately the very factors that produced yesterday's victories may now create tomorrow's losses. We need to change. But needing change doesn't make it happen, strong leadership, clear vision, and executable implementation plans do. Our future depends on them. Organizational survival is compelling all but the most brain-dead organizations to reinvent themselves. Innovative organizations are slashing costs, cutting cycle time, boosting quality and accelerating responsiveness. To make it all work, centralized hierarchies have been flattened, communication improved, and people have stopped taking orders from bosses and started taking responsibility for results.[40] DOD must do the same. And as the pace of change accelerates, we must move to stay ahead of it, always looking forward for better ways to evolve and grow - to innovate and implement. Organizations that fail to keep pace will not survive. Those that do embrace change must be as

Admiral Owens suggests "...unafraid of asking innovative questions and not afraid of the consequences."[41] They will flourish, doing so by implementing meaningful organization change.

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BREAKING THE MOLD-A CASE STUDY IN ACQUISITION REFORM

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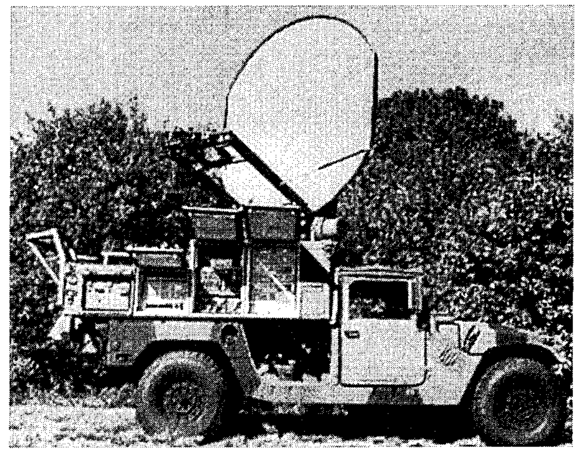
ABSTRACT

The Department of Defense (DOD) acquisition system is frequently criticized for its rigid compliance to an expensive, antiquated, and bureaucratic process. This process has been well documented regarding its inability to delivery current technology to the battlefield in a timely manner. This problem is especially acute in the military communications area where the rapid pace of technology results in design obsolescence within 18 months. In October 1993, the Department of the Army and the Army's Combat Development community challenged the acquisition community to procure and field a prototype combat communications system, the AN/TSC-143, Super High Frequency (SHF) Tri-Band Tactical Satellite Terminal (Tri-Band) to an operational unit in less than one year. The Program Executive Officer for Communications Systems (PEO COMM) and his Project Manager for Satellite Communications Systems (PM SATCOM) successfully responded to the challenge in an era before the Secretary of Defense, William Perry issued his Memorandum, "Specifications and Standards-A New Way of Doing Business," in June 1994. In fact, many of the bold initiatives outlined by the Secretary can also be found in reviewing the innovations implemented by the Tri-Band program team.



AN/TSC-143, TRI-BAND TACTICAL SATELLITE TERMINAL

The Tri-Band procurement is a prime example of how the acquisition process can be streamlined and serves as a standard by which the user community will measure the performance of the acquisition community in the future. The normal Procurement Administrative Lead Time (PALT), defined as beginning with the submission of an approved Procurement Data Package (PDP) by the PM, until contract award is estimated by the United States Army Communications Electronics Command (CECOM) to be approximately 234 days for a best value source selection of this dollar value. However, using a dedicated, focused "Team Fort Monmouth" approach, a select, highly motivated team achieved a contract award in only 72 days, a savings of 162 days or 70%. The total time from the initial phone call to start work on October 22, 1994, until contract award was only 154 days.

The objective of this paper is to provide the reader with an illustrative example of how acquisition streamlining can be achieved using a focused team approach.

BACKGROUND

During DESERT SHIELD/DESERT STORM, U.S. forces in Saudi Arabia established the largest most complex tactical satellite network in history using the DOD owned and operated satellites that comprise the Defense Satellite Communications System (DSCS). However, the DSCS could not provide enough capacity to support the deployed forces' huge and ever expanding demands for data intensive intelligence, logistics, and administrative information in addition to higher priority command and control communications. As a result, commercial satellite capacity and ground satellite terminals had to be leased from commercial vendors and operated by contract personnel at significant expense to DOD.

Numerous After Action Reports reiterated the need for military tactical ground terminals capable of accessing commercial satellites in order to augment the overloaded DSCS. Also, a series of General Accounting Office (GAO) reports criticized DOD for not using more commercial satellite communications in support of day to day peacetime operations, as well as in support of combat operations. However, DOD can neither rely on commercial vendors of satellite terminals to always be willing to deploy their personnel on the battlefield nor to remain in place should the potential for injury or capture increase to a level the individual may deem unacceptable. During the Gulf War, one contractor deserted his equipment the same hour the air war began, forcing military personnel to take over their equipment to maintain communications.

In the summer of 1993, the Army attempted to fund the procurement of SHF tactical satellite terminals capable of accessing not only the DSCS system in the X band (7900-8400 Mhz), but also the commercial Ku (14-14.5 Ghz) and C bands, (5850-6425 Mhz) i.e. Tri-Band capable, as part of the Commercial Space Package. The United States Army Space Command (USARSPACE) proposed that they be responsible for the procurement much to the dismay of the acquisition community.

At a follow-on meeting in September, USARSPACE lobbied for an increase in staffing of 13 personnel to conduct the acquisition. The PEO for Communications Systems, BG David Gust assured the community that he could procure these systems faster than any non-acquisition oriented organization and would not require additional manpower. Based on these assurances, the decision was made to assign the mission to PM SATCOM. However, attempts to secure funding under the Commercial Space Package were unsuccessful and further activity was suspended.

MISSION IMPOSSIBLE

On October 22, 1993, DA unexpectedly directed PM SATCOM to begin planning for the procurement of 6 prototype Tri-Band SHF Tactical Satellite Terminals using reprogrammed funds, not to exceed $9.9 million. PM SATCOM was also directed to procure the terminals on a Non-Developmental Item (NDI)/Commercial-Off-The Shelf (COTS) basis for operational use by the Power Projection for the Army Command, Control, and Communications (Power PAC3) Company.

The Power PAC3 Company was scheduled for activation in June 1994. These prototype terminals were to be capable of providing a complete communications package capable

of providing initial Command, Control, and Communications (C3) to a deployed Army Forces headquarters (ARFOR) and five liaison teams. DA stipulated that this be a one time procurement with a maximum quantity of 6 terminals. The possibility of including options for additional quantities was discussed, but was disapproved by DCSOPS.

Although the schedule dictated an NDI/COTS procurement, The United States Army Signal School demanded that these state-of-the-art Tri-Band terminals be fully capable of operating under battlefield conditions using military operators. Their requirements were very ambitious and presented a significant challenge to industry. The terminals were to have the capability of rapidly switching between SHF bands under field conditions using military operators and be mounted on a single Heavy High Mobility Multi-Purpose Wheeled Vehicle (HHMMWV) to include the antenna, an on-board generator, and an integrated digital switch.

To facilitate rapid force projection, a major terminal design requirement was the capability of being transportable by a single C-130 aircraft. At the time, six C-130's were required to deploy a similar C3 capability that still would not provide access to commercial satellites.

The Tri-Band Terminal was also required to provide a minimum data rate of 512 Kbps in C Band, 2 Mbps in X Band and 8 Mbps in Ku Band, a vast increase in capability over current tactical systems. Additional required capabilities were for hub-spoke operations and backwards compatibility with the current family of Ground Mobile Forces (GMF) tactical satellite terminals (AN/TSC-85/93/94/100).

The challenge to both the PM and to industry was to deliver this combat ready "prototype" satellite communications system to the unit by September 30, 1994.

THE TEAM CONCEPT

PM SATCOM implemented several key innovative initiatives at the outset of the program. On October 25, 1993, the PM established a Special Project Office staffed with existing CECOM matrix and PM core personnel tasked to provide support to the acquisition of the Tri-Bands. This action formed a dedicated, focused team with a common goal of delivering a quality product to the soldier in record time. The PM gave them "carte blanche" to make it happen, gave them good management support, then got out of their way. The team included members of the functional elements of CECOM that included the Research, Development, Engineering Center (RDEC) and the Command, Control, Communications, and Intelligence (C3I) Acquisition Centers and the Logistics and Legal Directorates. No additional personnel were added to organizations' manning documents for this procurement.

The team avoided a "business as usual" approach. From the beginning, the team adopted a zero based requirements philosophy in dealing with the functional support matrix. Each time the functional expert requested a Contract Data Requirement List (CDRL) item or demanded an action, a document, or the incorporation of a military specification (MILSPEC) or military standard (MILSTD) that didn't make sense, the requester was challenged to support its necessity. "Boilerplate" input to the specification or Statement of Work (SOW) provided by the matrix was

drastically tailored to fit the program or eliminated altogether

A key element for successful teaming in matrix support organizations is unity of command. CECOM management deserves special recognition in giving the PM full control of the matrix personnel on the team. Despite the fact that much hard work occurred over the holiday period, the PM was able to delay leaves and extend duty hours as required to maintain the schedule.

Essential to the team concept was getting the Combat Developer and the ultimate user on board as members of the team. In early November, 1993, key members of the team conducted a three day review of the first draft specification at Fort Gordon, Georgia. During this review, both the representatives from the combat development community and soldiers from the gaining unit were able to interface directly with the material developer and provide comment to the specification. Early and continuous involvement with these representatives during specification development, source selection, and testing was key in developing a sense of trust and confidence in the PM. This made the tough job of conducting cost-performance tradeoffs in light of cost and schedule constraints much easier.

An equally important member of the team was industry. Industry was brought into the program early by a Commerce Business Daily (CBD) announcement on November 10, 1993. The CBD announced a Briefing to Industry on November 22, 1993 and described the program. During that briefing, industry was provided a copy of the draft specification and requested to provide comments. In addition, one on one discussions were held the following day with every prospective offeror desiring to meet with the government team. Many productive comments and suggestions were obtained during both these sessions. Industry was kept informed throughout the PDP preparation through a continuous dialog with the team via an established Electronic Bulletin Board (EBB) system. A Pre-Solicitation conference was also held in January 1994 just prior to RFP release to give potential offerors one final chance to ask questions and again have one on one discussions.

The team was goal oriented, not functionally oriented. If an action didn't support rapid delivery, but only satisfied an administrative or bureaucratic requirement, the action was modified or deleted. The PM was challenged by the functional elements of CECOM demanding normal data requirements and adhering to policies more suitable for developmental programs. In each case, the PM insisted the team ask themselves four questions before reaching a decision:

Does it make good, common business sense?

Is it legal and ethical?

Is the functional requirement consistent with the intent of the program?

Is the PM willing to take the risk and be held accountable for the decision?

Problems were worked in parallel not in serial. Although the schedule demanded immediate solutions to produce a Procurement Data Package and award a contract, the team managed to look beyond that and simultaneously initiated other critical actions. The team was required to procure GFE, modify the HHMMWVs with

the 400 ampere alternator kits, and coordinate for operational testing.

Teaming improved productivity, enhanced the quality of the product, provided better customer support, and saved time. Normally, using the "business as usual approach," the PM would prepare a PDP, which would then undergo an arduous approval cycle that included a System Data Review Board, a legal review, and a contracting review. Instead, the individuals from these functional areas joined the team and actively participated in the development of the PDP and approved it as it was prepared. As a result, the approved PDP was presented to the CECOM contracting activity in on January 11, 1994. Because the highly motivated, innovative Contracting Officer assigned to the team from the first day thoroughly understood the program and had "done his homework," the Contracting Officer was able to release the formal Request For Proposal (RFP) the next day.

PULLING OUT ALL THE STOPS

Key to the success in this program was the high level management interest and support both within the Combat Development and acquisition community. Throughout the program, key managers in CECOM and the PM were willing to remove non-performing personnel who were unwilling to conform to a new way of doing business. Senior executives were willing to coach the team in the art of best value acquisitions of NDI/COTS equipment.

Another significant aspect was the willingness of our acquisition leaders to stand up to pressures from the user community who were indulging in "requirement creep". Throughout the procurement, and even up to the day before the release of the formal RFP, users, industry and consultants demanded last minute changes to the requirements. These changes would have, as a minimum, caused delays in the program and in some cases restricted competition. However, personal involvement by both the PEO and the CG CECOM kept the procurement on track.

The team implemented several initiatives to tailor this acquisition and to streamline the development of the PDP. The PDP used a functional or performance based specification that allowed the contractor to use his initiative on how best to satisfy the requirement. Although the team wrote the first draft specification to reflect the ideal requirements expressed by the user, it was tailored in coordination with the user to reflect what really was achievable in the time available. Industry comments and a good market analysis were key in convincing the user to re-look his opeerational needs and to establish his absolute minimum requirements. An Army Signal School two page memorandum served as the requirement document in the absence of a Mission Needs Statement (MNS) and Operational Requirements Document (ORD).

The Statement of Work (SOW) was limited to the absolute minimum essential requirements that could be satisfied by industry in the short time available. Many of the normal logistics, training and testing deliverables were tailored to meet the unique requirements of the program or deleted entirely. As a result, the number of data items was reduced from 41 to 11 during development of the PDP.

The key streamlining tool was the use of the Electronic Bulletin Board (EBB) to establish instantaneous communications with industry

and other government agencies. Each revision of the specification and SOW was placed on the EBB for industry comment. These comments were received and responded to by the PM via the EBB within 24 hours of receipt. It is particularly noteworthy that the Request for Proposal (RFP) was a "paperless solicitation," issued electronically by CECOM C3I Acquisition Center, only 24 hours after receipt of the PDP from the PM.

CORRALLING THE TEST COMMUNITY

Although these Tri-Band terminals would mostly consist of NDI and COTS components, they were required to interface with existing tactical communications systems, DOD strategic systems, and commercial systems. As a result, there was an extensive need for interoperability and performance testing. However, it was obvious that time and money did not allow the test community to conduct business as usual.

Four essential test events established by the PM were an In-Plant Acceptance Test, the DSCS and Commercial Satellite Certification, a Final Installation Acceptance Test conducted at the unit's location, and an OPTEC sanctioned Customer Test. The Test and Evaluation Control Office at Fort Gordon, Georgia would plan and supervise the test in a Field Training Exercise supported by military personnel from the gaining unit, the 11th Signal Brigade.

Most of the usual formal environmental, roadability, and airlift tests were deleted in lieu of the contractor providing an acceptable analysis confirming compliance to the PM's satisfaction. The team devoted a tremendous amount of rational thought and analysis in an effort to eliminate MILSPECs as much as possible. For example, generators are normally de-rated to allow operation at 10,000 feet above sea level. The team could not envision a scenario in which a major headquarters would be located above 7,500 feet. As a result, the operating specification was reduced to that altitude, allowing the use of a smaller commercial generator which in turn saved several hundred pounds in a severely constrained weight budget.

Interoperability testing and certification was a major concern as these terminals would be equipped with an newly developed, digital Switch Multiplexer Unit (SMU). The SMU had to be fully interoperable with the Mobile Subscriber Equipment (MSE) and Tri-Service Tactical Communications (TRI-TAC) family of switches as well as commercial networks. Just 30 days into the procurement, OSD published new guidance stating that no new switch would be fielded unless it was certified by the Joint Interoperability Test Center. Although the PM intended to thoroughly test this newly developed switch and to have it certified as interoperable by the JITC, the team knew that the schedule did not permit several months of dedicated switch testing nor did the contractor yet have an operational model for parallel testing.

The solution for interoperability testing was to involve the JITC early and up front and let them identify their interoperability concerns for incorporation into the test plan. High level management in JITC agreed to witness interoperability performance at each opportunity throughout the test program and not require separate formal testing prior to fielding. Designing interoperability in and testing it as part of first article testing or during other types of tests should be the model for interoperability testing in the future.

The elimination of some of the formal environmental testing for COTS/NDI procurements is an acceptable risk. Many of these items are fully capable of operating in a tactical environment if properly integrated into a suitable platform. In the case of the Tri-Band, COTS/NDI items would be mounted in a MILSPEC platform, the HHMMWV, inside a pallet assembly that provides a waterproof, environmentally controlled space. Analysis shows the components should operate satisfactorily. Experience in the field will either confirm or deny this over time.

EXPEDITING SOURCE SELECTION

Streamlining did not stop with the issuance of the RFP. Since the acquisition strategy demanded that the contract be awarded under conditions of full and open competition using a best value source selection, innovative techniques had to be implemented to reduce the normal time required for proposal evaluation, negotiation, and contract award.

The Chairman of the Source Selection Evaluation Board (SSEB) was highly experienced having completed five major evaluations over the previous five years. He proposed to the Source Selection Authority to only evaluate key discriminators given the limited time available. Logistics was a factor not evaluated during the source selection, since his experience indicated that, although important, logistics never had been a tie-breaker in a source selection. Traditionally, offerors' proposals state their systems are fully supportable and consistently underestimate the need for repair parts in order to reduce their bid. Instead, offerors were given a ceiling price for the initial spares and maintenance support, equalizing the logistics cost for all proposals and were required to submit a Maintenance Plan for the PM's approval within 30 days of contract award. The program management capability of the offerors also was not evaluated since the known potential offerors were all considered acceptable based upon prior history.

The offeror's proposal was limited to only 100 pages in addressing the technical factor in order to reduce superfluous text, thereby reducing evaluation time. Many of the functional matrix experts were upset at this decision because they felt we had ignored their particular area of expertise. One example was the expert in Human Factors, where the functional support element insisted on 100 pages for their area alone. Other functional areas that lobbied for more data during source selection was Logistics and Electro-Magnetic Interference (EMI).

The time consuming task of accomplishing Performance Risk Assessment during source selection had to be expedited. It was decided to initiate the process before release of the RFP by inviting all interested offerors to submit the required information early. All potential offerors were requested via the EBB on December 28, 1993 to submit the required information by January 10, 1994. This preliminary information in no way limited the information that could be submitted in the formal proposal. However, the early "jump-start" proved to be instrumental in meeting the schedule as requested information from Government sources was still being received in February.

The team also realized that there was not enough time to ask the offerors multiple rounds of questions or Items for Negotiation (IFNs) during source selection. As a result, IFNs were thoroughly scrubbed to ensure

they were comprehensive, clearly written and to the point. Unfortunately, offerors were required to get their response right the first time or risk being eliminated from the competition. This was absolutely necessary as the ambitious schedule did not allow time for a second round of IFNs or face to face discussions.

The source selection proceeded ahead of schedule with only one minor amendment to the RFP, issued electronically via the EBB, during the selection period. There were no official requests from the offerors for extensions of time in order to meet the source selection milestones. This was due to fact that the vast majority of the offerors' concerns were addressed during development of the RFP. The excellent communications established with industry, facilitated by use of the EBB, made this possible.

The high quality of the source selection process is further evidenced by the fact that despite the high level of interest by industry resulting in ten proposals, the contract was awarded ahead of schedule with no protests. The PM attributes this to continuous communications with industry throughout the process. A key factor in mitigating the risk of protests is taking all necessary measures to establish good communications with industry. The Government must tell industry how their proposals will be evaluated, maintain the integrity of the source selection process, and provide good debriefings to the unsuccessful offerors detailing why they were not awarded the contract.

The streamlined source selection not only reduced Government program costs, but also reduced industry's bid and proposal costs. We the Government frequently fail to appreciate the tremendous costs incurred by industry to prepare a proposal and retain the proposal team on the company payroll while the Government completes the source selection. Several of the unsuccessful offerors commented on the fact that although they would have liked to have won the contract, they appreciated the government keeping to the schedule and completing the source selection in record time, thereby minimizing their proposal costs.

Reducing industry's proposal costs may also reduce the risk of a protest as an offeror has made a smaller investment in an attempt to win a contract. One offeror commented that he had a proposal team on the payroll for two years awaiting award of another unrelated contract. He went on to state that if they didn't win the contract, he had no choice but to protest as he had to justify his investment to his management.

THE NEED FOR ADDITIONAL TEAM MEMBERS

Streamlining acquisition cannot be accomplished by the PM's team alone. The DA and DOD staff also need to re-look how they execute their oversight responsibility. Although the team was successful in pulling together Team Fort Monmouth, the DA Staff proved to be reluctant "to take to the field" and join the team in this procurement. The DCSOPS was quick to call in October 1993 to tell the PM to begin work. However, the formal Directed Procurement letter and funding was not received until January 7, 1994 five days before RFP release. The PM's task would have been easier, especially in dealing with outside agencies,

if the PM had written direction and funding from day one.

The Assistant Secretary of the Army (Research, Development, and Acquisition) staff joined "the opposition team" late in the game. In late June, just 90 days before delivery, they contacted the PM and insisted that they had to "get control of the program" as the PM was moving too fast. Despite the fact that this was a DA Directed Procurement for less than $10 million, they insisted that a Milestone Decision Brief be provided to PEO Command and Control Systems (CCS) who had just been made responsible for other Commercial Space Package (CSP) procurements. Although this decision was eventually reversed, it cost the team two man weeks of effort to prepare for and present briefings on why a formal Milestone Decision Briefing to PEO CCS was unnecessary.

CURRENT STATUS

Although the streamlined preparation of the PDP and award of the contract is a major success story, the contractor has had his problems meeting the ambitious delivery requirement of 6 months after contract award. Four of the six terminals have been delivered to Fort Huachuca, Arizona where they are undergoing a period of testing and fixing by the contractor. The government has demanded and received consideration from the contractor for delays and continues to demand that problems be fixed before unit training can begin. Although streamlining is important, the PM is adamant that he will not field a system to the soldier if he is not confident it will operate properly.

It is important for the reader to understand that problems encountered in the execution of this program are neither attributable to the streamlining innovations nor to the use of COTS/NDI components. They are attributable to the contractor underestimating the challenges of integrating these components into a complex battlefield system within the extremely short period of performance required by the contract.

Also, the test community should not view the current problems as the result of a lack of testing. The PM's abbreviated testing program successfully detected all technical problems prior to government acceptance of the systems and has successfully identified the deficiencies for correction to the contractor.

CONCLUSION

Adding the Tri-Band terminal to the U.S. Army's communications arsenal will permit the use of widely available commercial satellites as required by recent Congressional action and DOD guidance. This new capability will reduce the demands on the highly congested military satellite system. In addition to supporting Army and Joint operational requirements, these terminals will also be an important evaluation tool to provide valuable information to the Materiel Developer for future use in improving procurements of similar items.

The rapid acquisition of the Prototype Tri-Band terminal will dramatically increase the Army's war fighting capability by providing commercially available technology to the soldier before it becomes obsolete. This procurement also represents a unique opportunity to demonstrate the acquisition community's ability for rapid prototyping and streamlining the complex procurement process. PEO Communications Systems is

meeting the challenges in today's new acquisition environment and stands ready to rapidly field the best combat systems possible to the soldier of the future.

APPENDIX 1

THE SCHEDULE

22 Oct 93- PM SATCOM received telephonic notification to begin planning for the rapid acquisition of 6 prototype SHF Tri-Band Tactical Satellite Terminals

25 Oct 93-PM SATCOM established a Special Projects Office for the acquisition using detailed personnel

5 Nov 93 - Completed first draft of the specification.

8-10 Nov 93-PM SATCOM conducted meetings at FT Gordon, GA to further define user requirements, present the acquisition strategy, and to review the draft specification.

10 Nov 93 - Placed an announcement in the Commerce Business Daily that PM SATCOM was conducting a market survey for the Tri-Band terminal and that a briefing to industry would be conducted on 22 Nov 93.

10 Nov 93 - Placed formal solicitation announcement in CBD.

22 Nov 93 - Conducted briefing to industry. Handed out the second draft of the specification to industry which incorporated the input from the user community for formal comment.

23 Nov 93 - Conducted one-on-one discussions with potential bidders.

7 Dec 93 - Established a Tri-Band account on the existing Electronic Bulletin Board (EBB) used by PM MILSTAR.

9 Dec 93-Received a Memorandum from MG Gray, Commandant of the Signal Center detailing the minimum essential requirements for the Tri-Band.

10 Dec 93 - Placed second draft specification and the Executive Summary on EBB.

15 Dec 93- Established a Source Selection Board which included a select core of personnel with a high level of technical expertise and extensive experience in the source selection process.

17 Dec 93 - Placed statement of work (SOW) and the third iteration of specification which incorporated industry comments on the EBB

23 Dec 93 -Placed draft solicitation sections B, L, and M on the EBB. The addition of these sections informed industry on the required deliverables, how to prepare their proposal and how the proposal would be evaluated.

28 Dec 93- The KO issued an EBB message requesting all interested vendors to submit the necessary preliminary information for the government to evaluate the Performance Risk Assessment factor in advance of release of the RFP with a suspense of 10 Jan 94.

4 Jan 94-Conducted a Pre-Solicitation Conference and one-on-one discussions for all interested vendors.

6 Jan 94 - Received final comments from industry on all drafts via the EBB.

11 Jan 94 - Completed Procurement Data Package (PDP).

12 Jan 94 - Issued Request For Proposal (RFP).

11 Feb 94 - Received proposals from Industry. However, deadline extended to 14 Feb 94 due to a major east coast snow storm.

25 Feb 94 - Completed initial proposal evaluation.

1 Mar 94 - Conducted initial competitive range brief to Source Selection Authority (SSA).

1 Mar 94 - Released Items for Negotiation (IFN).

8 Mar 94 - Received IFN responses.

8 Mar 94 - Began Interim Evaluation.

15 Mar 94 - Completed Interim Evaluation.

17 Mar 94 - Briefed SSA on interim evaluation findings.

17 Mar 94 - Requested Best and Final Offer (BAFO). Also the KO sent out model contract to offerors still in competition and required they sign the contract and return with the BAFO.

21 Mar 94 - Received BAFOs.
22 Mar 94 - Completed final evaluation.
23 Mar 94 - Final briefed to SSA.
24 Mar 94 - Awarded contract 7 days ahead of our most optimistic schedule

APPENDIX 2

CONTRACT SYNOPSIS

A Firm Fixed Price contract for six Prototype Tri-Band SHF Tactical Satellite Terminals was awarded to GTE on 24 March 1994 in the amount of $7,756,801. The basic contract includes the hardware, initial spares, training, a systems level operator's manual and a time and materials effort for contractor maintenance and support for the first year (FY95). Delivery of all six terminals is required not later than 30 September 1994. In addition to the basic contract, ceiling prices were established for four 1-year depot level maintenance options for FY96 through FY99. These options are for time and materials only and are to be the responsibility of the gaining organization. The ceiling prices established with adjustments for inflation are as follows:

FY 96	$313,700
FY 97	$320,600
FY 98	$327,700
FY 99	$334,900

The contractor is required to provide depot level maintenance for the non-GFE components and technical support in the field throughout the life of the terminals (5 years).

COMMERCIAL PRODUCTS AND PRACTICES

A Prince in Commercial Rags

Robert E. Lloyd, CPCM
U.S. Department of State

ABSTRACT

One of the most widely discussed initiatives in recent years is the proposed use of commercial-style contracting procedures in the Federal Government. Under this approach, the State would act in the same manner as a private buyer, acquiring needed supplies and services more efficiently, as if it were not a sovereign. This paper analyzes the foundations of the concept in terms of legal precedent, political economy, and game theory in an effort to determine its likelihood of success.

The Federal Government serves two roles. It acts as a contracting party as any other enterprise in market exchange, but it also bears the privileges of sovereignty. The paper seeks to portray the divergent views of the State as sovereign and/or contractor and thereby help explain the apparent lack of progress in implementing commercial contracting methods. The dual nature of sovereignty in the United States necessarily complicates any proposals for reform of the current acquisition system based on best practices of industry.

INTRODUCTION

The Vice President's National Performance Review has recommended that Government contracting regulations "foster commercial practices," as part of an effort to make the Federal Government work better and cost less.[1] Once again,[2] Federal agencies are being asked to look to the private sector for good ideas to adopt in Government. Rather than addressing which buying procedures the Government should adopt or how it should acquire commercial items, this paper analyzes, at a more fundamental level, how the State should be regarded in a contractual setting. The Federal Government's twin role as both sovereign and contractor must be explored as a first step before starting any conclusive discussion of the ability or desirability of the State to emulate commercial contracting practices.

THE STATE AS CONTRACTOR

If the State were omnipotent, there would be no need for Government contracts. The Federal Government could simply obtain what it needed by seizure, condemnation, or other coercive measures.[3] The United States, however, has a system of limited government, so when the Federal Government needs something from an outside source to discharge its assigned functions, it must necessarily contract for those needs and enter the commercial market.

Recently, the Government even issued a statement as to the limits of its own authority to contract. Office of Federal Procurement Policy Letter 92-1 outlined areas where the Government may not contract out, i.e., inherently

governmental functions. If Federal agencies were truly sovereign, there would be no such limitation.

The courts have held that the Government, by entering into a contract, has rights and responsibilities similar to those of a private person who is a party to a contract.[4] As a contractor, Government must act fairly. The Government has been prevented from taking an action in its sovereign capacity where the action would violate elementary rules of fairness.[5] The Claims Court has ruled that our government is subject to general common law contracting rules, which limit the State's power, because entry into the field of contracts is not like the Government's creation of rights and entitlements in other fields.[6] This is consistent with Hayek's view that the service functions of government (such as contracting) should be separated from the law enforcement and national defense realm. The authority of the latter should not be conferred upon the former, and the State should have no special privileges in administering its programs.[7]

The State cannot adopt as its policy the repudiation of debts or the destruction of contracts, or for that matter deny the means to enforce them.[8] Although writing in a dissenting opinion, Judge Jones best expressed this overall position on the limits of Government action in a contractual setting: "Just because the Government has the sheer power to claim that a certain action was taken in its asserted sovereign capacity does not mean that a Government agency may disregard its voluntary contract obligations, nor that it may ride roughshod over the citizens' rights by simply donning the cloak of immunity without showing a necessity for doing so."[9]

The voluntariness of contracting applies to both the State and its counterpart contractor, since both reach agreement voluntarily in our capitalist economic system. Further, it has been said that the moral legitimacy of the State depends on its fulfillment of its contractual obligations.[10] This principle is evident in the longstanding law of breach of Government contracts, for recovery is based on the principle of restitution where that remedy would be available if the Government were a private contracting party.[11] Contractors are likewise not required to comply when the Government makes cardinal changes to a contract.[12] Instead of being subject to the whims of an omnipotent buyer, a contractor selling to the Government may recover if the Contracting Officer acted in an arbitrary, capricious, or malicious manner.[13]

The Supreme Court has distinguished between the Federal Government acting as a market participant versus a market regulator.[14] The standards of behavior are not the same in both realms. In a related development, boards of contract appeals have recently begun to recognize that a Government agency, though presumed to act in good faith, is an organization motivated to behave in the same way as any other private party seeking a contractual advantage.[15]

The law governing most commercial contracts, the Uniform Commercial Code (UCC), even applies on occasion to Federal contracts. It is well established that, in the absence of a statute or

regulation, the interpretation and construction of Government contracts will be governed by principles of general contract law. The UCC is regarded by the courts and boards of contract appeals as law applicable to Government contracts.[16] Although Federal laws and regulations generally cover most contracting situations, the fact that the UCC does apply in some circumstances is another example of how the State is sometimes treated as just another contractor.

An additional way in which the State is regarded in the same manner as a private concern is, oddly enough, in the application of the so-called sovereign acts doctrine. The Supreme Court has decided that, although the doctrine of inherent sovereignty does not apply to the Federal Government, the United States, as a party to a contract, is not liable for breach of its "proprietary and corporate contracts due to its public and general acts as a sovereign."[17] In other words, if Agency X has a contract with Company Y, and Agency Z (or even an office other than the contracting office in Agency X, or Congress) takes an action of a public and general nature (i.e., not specific to the contract at hand) that affects Company Y's contract (typically, increasing costs or interfering with the work), then the sovereign acts theory bars recovery by Company Y for this disruption to its contract.

One reason argued by the courts in favor of this concept is that the Government should not be liable contractually for acts taken in a sovereign capacity for the public good.[18] The Claims Court has ruled that the sovereign cannot forever waive its rights to exercise its sovereign powers unless it expressly reserves the right to do so in the contract.[19] It is said that to rule otherwise would mean that one Congress could lock the Government into binding contracts involving areas that a future Congress would be powerless to legislate on, producing a result in which the legislature could not be responsive to its citizens.[20] Additionally, it has been claimed that the sovereign acts defense is necessary so that private parties will not be able to obtain immunity from State regulation simply by making private contractual agreements.[21] Nevertheless, the doctrine has its limits. Contracts, even those with the Federal Government, are not subject to unlimited modification under the police powers of the State. The State may only impair contracts if reasonably necessary to serve an important public purpose.[22]

Another rationalization for this treatment of contractors is that in the case of private parties to a contract, the burden of a change in the law is usually borne by the party on which it falls, absent specific contract wording to the contrary. Under the sovereign acts doctrine, parties contracting with the Government will only have rights against the State that would be available against a private company. If a contractor brought an action against a private corporation due to acts of the Federal Government, it could not be sustained. The United States is not held to a greater liability than other contractors in court.[23]

Although the sovereign acts doctrine superficially (and conveniently, for the Government) considers the State as simply another corporate entity, the fact remains that from a contractor's

perspective, the sovereign acts doctrine may also be viewed as yet another weapon in the State's arsenal of defenses. Despite the fact that the Federal Government is not monolithic,[24] and one agency is not responsible for the acts of a sister agency, to a contractor the sovereign acts doctrine absolves the State for liability from its actions as a whole. The theory offers little consolation to affected firms, even though its purported justification is to treat Government and contractor as equal trading partners in the market.

A further defect in the sovereign acts doctrine is that it encourages Congressional profligacy. If a legislature is empowered to pass laws without regard to their impact on existing contracts, there will be little stopping the enactment of legislation that will be burdensome and costly to private industry. This can hardly be consistent with ongoing attempts to obtain more competition in Government contracts. Commentators have also pointed out that there is no limit to the types of acts that might potentially qualify for protection under the sovereign acts doctrine, ranging from protection of the environment to controlling inflation.[25] The standard of "public and general act" has been roundly criticized as a weak protection for contractors, since all legislation is supposed to be for "the public good."[26]

The sovereign acts defense rests on the theory that Government actions may be either of two characters: acts in a proprietary capacity (as a contractor), or acts in a sovereign capacity (as the State).[27] Nevertheless, in one sovereign acts case, the Court of Claims insisted that "the two characters which the Government possesses as a contractor and as a sovereign cannot be thus fused."[28] Theory aside, the sovereign acts doctrine is an example of how the dual public/private nature of the State produces unpleasant results from an industry perspective in the field of Government contracting.

Another instance of how dealing with the State as a contractor results in a disadvantage to private contractors concerns the Government's right to set terms and conditions in its contracts. The landmark Perkins v. Lukens Steel Company case that denied standing to a contractor suing the Government over objectionable solicitation provisions presented the Supreme Court's position that the Federal Government "enjoys the unrestricted power to produce its own supplies, to determine those with whom it will deal, and to fix the terms and conditions upon which it will make needed purchases."[29] What is curious is the reasoning given by the court for this stance, namely, that the same outcome would occur among private individuals, who are free to write contracts in any manner they please. Although this is largely true under the UCC,[30] it presents a paradox, for if we treat the State as a contractor, the Government arguably gains unlimited power in contracting. Those who would speak in favor of adopting commercial practices in Government contracting should be mindful of this result.

THE STATE AS SOVEREIGN

Despite the legal precedent for holding the State to the same standards of conduct as a private firm, there is a

corresponding body of thought that holds a contrary view. In the early years of the Republic, Alexander Hamilton wrote: "Contracts between a nation and individuals are only binding on the conscience of the sovereign, and have no pretension to a compulsive force. They confer no right of action independent of the sovereign will."[31] The reason for this argument was that even before the Constitution was passed, all States had enjoyed sovereign immunity.[32] This concept has survived, but only to a limited degree in Government contracts of this century. A famous instance in which the Federal Government was ruled not to be just another contracting party was the Federal Crop Insurance Corporation case of the 1940s. In this case, the Supreme Court denied standing to a party bringing suit against a Government-sponsored enterprise, explaining that the Government is not just another private litigant and cannot be charged with liability as the sovereign.[33] Despite the clarity of its pronouncements, the case is of little import for contemporary Federal acquisition, because in the past few years, the Federal Government has increasingly waived its sovereign immunity in contracting.

In addition to providing special contract dispute resolution bodies, Congress has passed laws greatly expanding the bid protest mechanism, ostensibly for the purpose of making the Federal acquisition system more fair and responsive to the complaints of commercial firms who are unsuccessful in winning contracts.[34] But does the Government's stepping down from a position of sovereign power make it more like a commercial buyer? The answer is clearly no, because commercial sellers have no rights of protest against contract awards made by private buyers, whether under the Uniform Commercial Code or common law of contract. Ironically, by making the State less "sovereign" in power, we have also made it less resemble a commercial contractor.

Several authors have compared commercial and Government contracts and found key areas of difference. The most frequently cited "burdens" are the sovereign's right to terminate for convenience, and its power to make unilateral changes to contracts.[35] A review of commercial contracts shows this position to be weak. Commercial contract terms and conditions used by several firms include changes and termination for convenience clauses nearly identical to those included in the FAR.[36] This may be partly due to the fact that the UCC allows the parties to create their own contracts within very wide boundaries. Adoption of UCC principles of commercial contracting would produce surprisingly unpleasant results for private industry in other areas as well. Under the UCC, there is also no need for public notice of upcoming contracts, competition, or even necessarily a written solicitation.[37] Obviously, in this respect, to regard a Government agency as a sovereign with unique contracting rules is to the advantage of private firms over the alternative of following commercial practices.

One of the true manifestations of sovereignty in Federal contracting involves the Government contractor defense. In many cases, firms working on Federal contracts have been held to be

immune from tort liability if an injury or death occurs as a result of a failure of equipment produced under a Government contract.[38] The justification for this defense is that a private firm should be protected if it is simply executing the will of the State. The underlying assumption is that without immunity, no one would be willing to compete for Government contracts of such a nature. Nevertheless, despite the apparent fairness of this doctrine from the perspective of the private contractor, it has been criticized for victimizing innocent civilians for occurrences that could either be covered by insurance or should be factored into a firm's cost-benefit analysis when deciding to enter the Government contracting arena.[39] Such criticism illustrates again how our views of the sovereign are clouded by ambiguity.

The paradox of the State as contracting party appears in many forms, including a Court of Claims decision regarding the role of the Government's Contracting Officer. The court opined that the Contracting Officer serves a dual role, that of a representative of the State and that of an impartial arbitrator of disputes. He or she "must not act as a representative of one of the contracting parties, but as an impartial, unbiased judge." Nevertheless, the Contracting Officer's findings of fact are presumed to be conclusive, absent evidence that they are arbitrary or capricious.[40] Even at the most individual level, legal precedent holds the State to a different standard than ordinary commercial parties.

Along these lines, one of the most frequently heard excuses for having different rules for contracting with the sovereign than for commercial contracting is that Federal contracts spend taxpayer money. The argument fails upon further analysis. The assumption put forth is that the State must be especially careful in how it spends its tax dollars. The implication is that when an individual citizen spends his or her own money, there is no concern for how wisely it is spent. Few people would agree with this proposition. Alternatively, this theory implies that commercial buyers are under no pressure to spend shareholder dollars wisely. Clearly, this is not the case. Therefore, the proposition that Government should be accorded deferential treatment simply because it is in charge of protecting taxpayer funds is a specious one.

There remain valid reasons why the State does not and cannot, under current law, behave more like a private firm when it contracts. In the purely commercial world, there are several governance structures available to help preserve the existence of trade relationships. These include trading only with one's friends, concerns about loss of future sales, or use of vertical integration. For the Federal Government, only one governance structure is available: formal contracts, upon which almost complete reliance must be placed. It is only natural for the State to resort to lengthy contracts that bear little resemblance to private agreements.[41]

Yet at a more basic level, the paradox or contradiction inherent in U.S. Government contracting merely echoes the foundation of our form of government itself: the principle of popular sovereignty. In America, fairness and certain standards of behavior

are expected from the State because ours is a government founded on the premise that all power resides in the people, except where government, as a creature of its human founders, has been granted limited authority in the service of the populace.[42] As the doctrine of divine right of Kings came into disrepute, it gave way to the idea of the sovereignty of the people in seventeenth century England, and was popularized during the American Revolution. Edmund Morgan[43] points out that both theories require the suspension of disbelief and serve as convenient fictions to persuade the many to submit to the government of the few.

There is a circular logic in creating a government comprised of citizens representing "the people" and thereby posing the question of who is left to protect the citizens from the arbitrary acts of a government that is popularly elected or supposedly controlled by elected officials. Another author refers to the "dilemma of representative government" and describes its basic precept as self-contradiction, hypocrisy, and illusion,[44] for to complain about government in a nation founded on self-government is to criticize oneself. This tension lies at the core of democratic government.[45]

The success of popular sovereignty has always rested on a fragile base of representation, with power exercised only by agents of the populace who were simultaneously representatives of the people and wielders of supreme power.[46] This same ambiguity, derived from the contractual basis of American democracy, carries over to Government contracting as well. The State is expected to be a contracting party and a sovereign at the same time. Those who would complain about the State's inefficiency compared to commercial contracting would also demand the Federal Government to be fair and consistent in its practices, even though these two goals are often in conflict.[47]

Economic philosophers have pointed out this conflict in several aspects. Bertrand de Jouvenel notes that although the individual may be sovereign in a democracy, his sovereignty is a power almost always held in abeyance.[48] Holcombe states that the danger in social contract theory inherent in representative democracy is that it can be used to justify coercion by arguing that those being coerced agreed to a social contract and now must abide by the Government's rules.[49] This dilemma is just as acute for the commercial firm that pursues Government business.

WHY PLAY THE GAME?

After looking at the ways in which the State may invoke its sovereign powers, we may find it only natural that companies should refuse to compete for Government contracts. Indeed, regulatory controls have been cited as a barrier to entry in Federal acquisition.[50] But the reality is that the contracting agency's status as a sovereign does not figure prominently when companies are surveyed. Lamm's study of over 400 firms revealed that the most frequently cited reasons why firms refuse DoD business were, by far, burdensome paperwork and Government bidding methods,[51] and not a perceived inequality of bargaining power.

If contracting with the sovereign is such a bad deal, then why are contractors still interested in Government business? Epstein argues that it is improper for the Federal Government to impose conditions on firms or private parties in a contract that would elsewhere be considered unconstitutional.[52] Although his argument is compelling, few companies seem to be listening. Perhaps this is because, as Epstein confesses, each firm acting alone may feel that it is in its interest to give up some constitutional right, even though as a group, all contractors would reach the opposite conclusion. Hence firms continue to do business with the Government despite objectionable terms and conditions. Another explanation for this behavior lies in game theory, which can be employed to show how it is rational for contractors to submit to the Government's terms and conditions in contracting.

A Prisoners Dilemma scenario illustrates the choices facing contractors in deciding whether to compete for Government contracts. In the following diagram, to comply means to compete for the Government contract on the Government's terms, as stated in the solicitation. To resist means to refuse to abide by these terms and not to submit an offer at all.[53] The diagram is a two-person, zero-sum game in which there are only two possible competitors for a Government contract (a situation which may not be the most common but one which is certainly not unknown).

		A	
		Comply	Resist
B	Comply	7.5, 7.5 II	5, 10 I
	Resist	10, 5 III	5, 5 IV

An explanation of the values in each quadrant or payoff box is as follows:

I: This quadrant represents the fact that if A refuses to deal on the Government's terms, B will become the sole source supplier to the Government, and their revenues become 5 and 10 monetary units, respectively. Even if this condition did not hold and there were more than two firms in the relevant market, B would still have a better chance at getting a Government contract, in light of the reduced competition resulting from A's departure.

II: If both firms go along with the Government's terms and conditions, however unreasonable, they have a chance to increase their revenue (to 7.5 units) through participation in the market for Government contracts. Note that the potential payoff is less than the highest value available in quadrants I and III, because both A and B must compete for the contract, and each presumably has only a 50% chance of winning.[54]

III: This is converse result to quadrant I, where B opts out, leaving A in line for the contract.

IV: In this quadrant (as well as in sectors I and III), the value 5 represents

the fact that each firm has commercial business and is not completely dependent upon Government contracts, although it is recognized that some firms do not fit this profile. If both firms opt out of the market for Government contracts, they will still have income. Perfect competition need not exist in the commercial market for this result to hold true.

In addition to the many instances where Government buying rules are more favorable to companies than commercial practices under the UCC, game theory shows us why it is understandable for firms to seek Government business even when they do not like the terms. While some may claim that commercial practices are better or more advantageous to private industry, companies still find it rational to enter the field of Government contracting.

CONCLUSION

The premise of contemporary efforts to make Government more business-like in its contracts is that the State and the private corporation can be considered equals. Legal precedent supports the view of the State as contractor in several respects, but there are still remnants of sovereign immunity and other areas where the Federal Government as buyer cannot be placed on the same footing with its commercial partner. This inconsistency is not surprising, given the nature of our government where power and authority are established on the paradoxical basis of popular sovereignty. It then becomes understandable for private industry to complain of Federal acquisition rules while at the same time finding it rational to play the game.

To borrow a phrase, the push for commercial-style contracting by the Federal Government is a policy at war with itself.[55] The adoption of commercial contracting procedures might streamline Federal acquisition at the expense of private industry. Acquisition policy makers should realize that a tradeoff is involved in discarding Government-unique procedures for industry practice. Whether we want the prince to wear commercial rags rather than the sartorial trappings of sovereignty is a question demanding that we look beyond appearances. Before we blindly accept the proposal that commercial practices will solve the problems of today's acquisition system, we should be aware of the larger implications that face us when we view the State as a one-dimensional entity. As long as the State serves a dual role, the application of commercial practices to Federal contracts will remain an elusive goal.

ENDNOTES

[The views expressed are solely the author's and do not necessarily represent those of any U.S. Government agency. The title of the paper is derived from a passage in James O. Mahoy, ed., Government Contract Law (USAF/AFIT, 1979), 27.]

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1 Al Gore, From Red Tape to Results: Creating a Government that Works Better and Costs Less (Report of the National Performance Review: September 7, 1993, GPO), 28.

2 The applicability of private industry techniques has long been questioned in a

governmental context; see, e.g., Brian W. Rapp, "You Can't Manage City Hall the Way You Manage General Motors," in Frederick S. Lane, ed., Current Issues in Public Administration (New York: St. Martin's, 1978), 416-421.

3 Mahoy, 27. Some would argue that even a despotic government would agree to limit itself in the interest of self-preservation, to lull the populace into a false sense of security; Anthony de Jasay, The State (New York: Basil Blackwell, 1985), 191-192.

4 G.L. Christian and Associates v. U.S., 312 F.2d 418, 423 (1963).

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6 Torncello v. U.S., 681 F.2d 756, 762-763 (1982).

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9 Air Terminal Services, Inc. v. U.S., 165 Ct. Cl. 525, 536 (1964).

10 David B. Toscano, "Forbearance Agreements: Invalid Contracts for the Surrender of Sovereignty," Columbia Law Review 92:2 (March 1992), 449.

11 Acme Process Equipment Co. v. U.S., 171 Ct. Cl. 324 (1965).

12 Airprep Technology, Inc. v. U.S., 13 FPD 18 (Fed. Cir. 1994).

13 Daniel E. Toomey, William B. Fisher, and Laurie F. Curry, "Good Faith and Fair Dealing: The Well-Nigh Irrefragable Need for a New Standard in Public Contract Law," Public Contract Law Journal 20:1 (Fall 1990), 87-125; Gonzales v. Freeman, 334 F.2d 570 (1964).

14 Phillip M. Kannan, "Perkins v. Lukens Steel Company: Fifty-two and Counting," Public Contract Law Journal 22:3 (Spring 1993), 463-476, citing Hughes v. Alexandria Scrap Corp., 426 U.S. 794 (1976).

15 Toomey, et al.

16 Priebe & Sons v. U.S., 332 U.S. 407 (1947); American Ship Building Company v. U.S., 228 Ct. Cl. 220 (1981); ASBCA 12174, Garrity Corp., 67-2 BCA 6586; ASBCA 9030, Reeves Soundcraft Corp., 64 BCA 6317; ASBCA 33,317, Coronado Technology, Inc., 88-3 BCA 20,983; AGBCA 296, Robichaux Contractors, Inc., 72-1 BCA 9302.

17 Perry v. U.S., 294 U.S. 330, 334 (1934). The first use of this defense was in Deming v. U.S., 1 Ct. Cl. 190 (1865), in which a Marine Corps contractor was denied recovery for increased costs under a rations contract due to new statutes enacted by Congress. It should be noted that sovereign acts are considered an excusable delay under the FAR Default clause (see 52.249-8(c)(2), which allows acts of the Government in either its

sovereign or contractual capacity as a basis for a valid excusable delay).

18 Atlas Corp. v. U.S., 895 F.2d 745, 754 (1990).

19 Hughes Communications Galaxy, Inc. v. U.S., 26 Cl. Ct. 123, 137 (1992).

20 Winstar Corp. v. U.S., 994 F.2d 797, 810 (1993).

21 Unites States Trust Company of New York v. New Jersey, 431 U.S. 1, 22 (1976).

22 Ibid., 22, 25.

23 Winstar, 808; Deming v. U.S., 1 Ct. Cl. 190 (1865).

24 Charles T. Goodsell, The Case for Bureaucracy (Chatham House, 1983), 111.

25 Ronald G. Morgan, "Identifying Protected Government Acts under the Sovereign Acts Doctrine: A Question of Acts and Actors," Public Contract Law Journal 22:2 (Winter 1993), 223-233.

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27 Robert C. Gusman, "The Winstar Case: A Study in Abandonment," Federal Contracts Report (October 25, 1993), 440.

28 Jones v. U.S., 1 Ct. Cl. 383 (1865).

29 310 U.S. 113 (1940).

30 See Uniform Commercial Code, Section 1-102, which allows the parties to establish any contract terms based on commercial practices or customs, as long as the underlying principles of good faith, diligence, reasonableness, and care are upheld.

31 Quoted in Thomas S. Williams v. U.S., 289 U.S. 553, 575-578 (1933).

32 The Federalist Papers, No. 81 (Hamilton), (New York: New American Library, 1961), 487-488.

33 Federal Crop Insurance Corp. v. Merrill, 332 U.S. 380, 383 (1947).

34 The Competition in Contracting Act, with its bid protest procedures, was an explicit waiver of sovereign immunity; Grumman Data Systems Corp. v. U.S., 12 FPD 71 (Fed. Cir. 1993).

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Company, Purchase Order Terms and Conditions (D1 4100 4045, Rev. 4/83).

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40 Penner Installation Corporation v. U.S. 89 F. Supp. 545, 547-548 (1950).

41 Christopher N. Lee, "Government Contracting: A Game-Theoretic Analysis," Public Contract Law Journal 19:2 (Winter 1990), 382-292.

42 See, generally, Randy Barnett, ed., The Rights Retained by the People (George Mason University Press, 1989).

43 Inventing the People: The Rise of Popular Sovereignty in England and America (New York: Norton, 1988).

44 Stephen L. Collins, From Divine Cosmos to Sovereign State (New York: Oxford, 1989), 168.

45 Susan Rose-Ackerman, "The Economic Analysis of Public Law," European Journal of Law and Economics 1:1 (March 1994), 64.

46 Morgan, 237.

47 Herbert Kaufman has demonstrated how Federal "red tape" develops by popular demand; Red Tape (Washington, DC: Brookings, 1977), 29-59.

48 The Nature of Politics (New Brunswick, NJ: Transaction Publishers, 1992), 198-206.

49 Randall G. Holcombe, The Economic Foundations of Government (New York University Press, 1994), 168.

50 William E. Kovacic, "Regulatory Controls as Barriers to Entry in Government Procurement," Policy Sciences 25 (1992), 29-42.

51 David V. Lamm, "Why Firms Refuse DOD Business: An Analysis of Rationale," National Contract Management Journal 21:2 (Winter 1988), 49.

52 Richard Epstein, Bargaining with the State (Princeton University Press, 1993), 79, 312.

53 Although this "all or none" environment is the most common, another scenario exists (except when using sealed bidding): submitting an offer containing a list of exceptions to the "boilerplate," since FAR 1.4 allows agencies to grant deviations from the regulations.

[54] It should be noted that the value of 7.5 would be reduced to a number closer to 5.1 if the dollar amount of Government business constituted only a small fraction of the firms' total business. This is the case for Government purchases of jet fuel; Christopher N. Lee, Consequences of Constrained Governance: A Comparative Analysis of DoD Jet Fuel Contracting (George Mason University, PhD. Dissertation, 1990), 141.

[55] Robert H. Bork, The Antitrust Paradox: A Policy at War with Itself (New York: Basic Books, 1978).

MULTI-VENDOR SUPPLY CONTRACTS -
A NEW METHODOLOGY OF CUSTOMER SUPPORT

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ABSTRACT

Multi-Vendor Supply Contracts (MVSC) is a new type of contracting combining the advantages of both Multiple Award Schedules (MAS) and Special Order Programs (SOP). It permits the end-using customer to obtain relatively complex to extremely complex commercial products based upon their specific needs and their budgetary requirements. There are several distinctive advantages in the use of MVSC:

From the customer's point of view, they are able to obtain a commercial product from one of a myriad of suppliers which can meet their specific needs. In addition to the above, they are able to obtain a product in a timely fashion with delivery time significantly reduced from "normal" procurements methods such as firm fixed price (FFP) definite quantity buys. They are also able to obtain products at an extremely competitive price - typically equal to or better than the pricing in a definite quantity procurement.

From the contractor's point of view, the products being offered, and purchased, are what they make and sell commercially. As such, they are not required to meet a government specification. In addition to the above, the contractor need not expend its resources in responding to several solicitations, each one for a specified quantity where contract award is based, in many cases, strictly on lowest price with little consideration given to technical capability or quality.

From the contracting office's point of view, it permits a broad spectrum of commercially available products from which orders can be fulfilled timely with a limited staff. It also saves the contracting office significant time and moneys in avoiding such items as written government specifications, and the significant costs of preparing and issuing solicitations, evaluation of offers, and contractual award for each individual requirement.

The main strength and selling point of the MVSC program is its ability to provide a needed product in a timely manner at a reasonable price. In this era of reinventing government, the MVSC program streamlines the procurement process to the benefit of the contracting office, the contractor, and the federal government customer agencies.

MULTI-VENDOR SUPPLY CONTRACTS -
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In order to help fulfill its mission, the General Services Administration (GSA) created a new, unique, and innovative form of contracting in March of 1991. The program, called Standardization and Control of Industrial-Quality Tools (SCIT), is the first Multiple Vendor Supply Contract (MVSC) in existence. This program is a stock program for the purchase of tools used for airplane maintenance and repair.

Since 1991, the use of Multiple Vendor Supply Contracting has become more prevalent due to the use of Industrial Funding and recurring unique requirements in the Government's procurement sectors. Currently, the MVSC program has extended into non-stock areas MVSC has enabled GSA to better fulfill its mission through the supplementation of its multiple-award schedule (MAS) program.

Congress has shown how popular the MAS program has become. In a proposed bill by United States Representative John Conyers, Jr., the following opening remarks were made:

Federal agencies each year order approximately $5 billion in goods and services from 'multiple award schedule' contracts awarded by GSA. This program is extremely popular with Government contracting officers, because they are able to place orders from vendor schedule contracts, sort of like ordering from a Department store catalog, bypassing many of the requirements of the Federal contracting system. It has also become extremely popular with schedule contractors as a result of the profits to be made from this 'fast-track' method of Federal contracting.

The above figures may soon become a gross underestimate of MAS sales volume for future years. According to Title I, Subtitle E, Part II of the Federal Acquisition Streamlining Act of 1994 (The Act), Federal supply schedules can now be used by State and local governments, Puerto Rico, and Governments of Indian tribes. Section 1555 of The Act amends subsection 201 of the Federal Property and Administrative Services Act of 1949 as follows: . . . The Administrator [of GSA] may provide for the use of Federal supply schedules of the General Services Administration by any of the following entities upon request:
'(i) A State, any department or agency of a State, and any political subdisvision of a State, including a local government.
'(ii) The Commonwealth of Puerto Rico.
'(iii) The government of an Indian Tribe . . .
(Federal Acquisition Streamlining. . .)

MVSC is very similar to (MAS) contracting in theory and practice. It is an attempt to solve current procurement problems through

the use of "innovative customer support" (Schroyer).

On July 24, 1990, Solicitation Number FCEP-BB-90NADPB-N was issued for Industrial Quality Precision-Measuring and Pneumatic Hand Tools. In it, the Statement of Work's Objectives state:

This solicitation for industrial quality tools is designed to meet the following objectives: a. Establish a new source of supply which will provide those customers, actively involved in tool standardization and control, with a vehicle whereby they can:
1. Choose Correct items necessary to be used by artisans/mechanics in their performance of many various disciplines and tasks associated with aircraft maintenance and aerospace applications in support of critical weapon systems.
2. Choose items to support activity-unique tool standardization and control programs (i.e., shadow box, vacuum formed tool cabinet drawer inserts, random inventory, total accountability, or other method).
3. Choose compatible replacement items ensuring continuity, uniformity and economy in the standardization and tool control program.
b. Maintaining a separate, specialized stock of these highly critical use tools to provide supply support in the case of a national emergency. (Solicitation Number FCEP-BB-90NADPB-N, p. 6)

Due to the fact that Multiple Vendor Source Contracting works similarly to MAS contracting. Federal Acquisition Regulation (FAR) 8.405-1, entitled, "Ordering from multiple-award schedules," applies to both types of procurements. FAR 8.405-1 says,

When ordering from multiple-award schedules, ordering offices shall use the procedures set forth below. When these procedures are followed, orders placed against schedules will result in the lowest overall cost alternative to meet the needs of the Government.
(a) Orders should be placed with the schedule contractor offering the lowest delivered price available. The ordering office shall review the schedule price lists that are reasonably available at the ordering office. Where the ordering office has available fewer than three price lists from current schedule contractors that offer the required items, the ordering activity shall obtain additional price lists from schedule contractors listed in the GSA schedule for the required items. The ordering office shall fully justify in the contract file orders for a line item exceeding the price reasonableness verification threshold at 13.106 placed at other than the lowest price identified in its review. Justification for ordering a higher priced item may be based on such considerations as -
(1) Delivery time in terms of actual need that cannot be met by a contractor offering a lower price;
(2) Specific or unusual requirements such as differences in performance characteristics;
(3) Compatibility with existing equipment or systems;
(4) Trade-in considerations that favor a higher priced item and produce the lowest net cost; and
(5) Special features of one item not provided by comparable items that are required in effective program performance. . . (Federal Acquisition Regulations, Federal Acquisition Change 90-5, p. 8-11)

The above justifications still apply in MVSC and are received on a regular basis. Upon

occasion, the customer agency fails to provide a justification and GSA must then ask the agency for the justification to be forwarded before the order is placed.

The Competition in Contracting Act (CICA) has acknowledged the use of Multiple-Award Schedules as a valid exemption. CICA states, in part, that,

. . . The term 'competitive procedures' means procedures under which an executive agency enters into a contract pursuant to full and open competition. Such term also includes-. . ."(3) the procedures established by the Administrator for the multiple awards schedule program of the General Services Administration if-"(A) participation in the program has been open to all responsible sources; and
"(B) orders and contracts under such procedures result in the lowest overall cost alternative to meet the needs of the Government. . . (United States Statutes at Large. . . p. 98 STAT.1180)

In the use of MVSC contracting, the procedures for contractual award are carried out as if the firm was submitting an offer for an MAS schedule contract. Discount schedule and marketing data are requested (Solicitation FCEP-BB-90NADPB-N, pp. 45 - 54) and each offer is negotiated on its own merits as if it were an MAS contract.

On December 22, 1987 Public Law 100-202 amended Section 109 of the Federal Property and Administrative Services Act of 1949. Before this amendment GSA was only authorized to charge the direct funding of a specific procurement to the ordering agency (typically used in a definite quantity requirements contract) (Loewentritt). After Public Law 100-202 was signed, GSA was given the authority to charge indirect funds, overhead, and contracting. In essence, GSA became industrially funded and the statute stated that anything procured through the General Supply Fund could receive a mark-up because of GSA's status as the primary contracting office. Until the use of MVSC, GSA has only used this mark-up on stock and special order contracts (SOP) (Loewentritt). The MVSC contracts allow GSA to recoup some of the costs associated in establishing these contracts.

MAS allows all ordering agencies to purchase directly from the contractor from the contracts. In MVSC, however, the firm submits a requisition to GSA who then purchases the product on the behalf of the customer agency. GSA, once the product is delivered, is billed by the contractor. GSA then pays the contractor and bills the customer agency the invoice price plus a surcharge. Said surcharge varies by commodity center and, in some cases, product line within the commodity center.

The surcharges stated above are calculated based upon two factors: The projected sales of the Commodity Center and the projected costs incurred by the Commodity Center. Ideally, if all projections are accurately portrayed, at the end of the fiscal year the Commodity Center should break even. Typically, the sales figures or costs are not entirely accurate. FCA, for example, had projected sales of $472.2 million for fiscal year 1991. As of July 1991 (10 months into FY 1991) the center had sales of $604.4 million (Feit Memorandum). At the same time, 6FE-CO had projected sales of $46.7 million and only achieved $27.6 million for the same time period (Feit Memorandum).

The revenue of FCA, based upon the above, is $2.6 million above what was anticipated, however 6FE-CO is $1.1 million lower than anticipated (Feit Memorandum).

MVSC's primary area of use is in the fulfillment of unique requirements (Schroyer). It is not designed to replace, but rather, to supplement the MAS contracts. In addition to the above, the main purpose of MVSC is not to make money for GSA, but to support GSA's customers. Mr. Gormley emphatically states that, "Industrial Funding is not the issue - efficient customer support is the issue" (Gormley). This attitude is re-emphasized by Larry Schroyer who states, "The primary reason is not to make money but to increase services [to the using agencies]" (Schroyer). The theory behind MVSC is that if one is able to meet and exceed customer expectations and needs, then the customer will be more willing to use this non-mandatory source in the procurement of necessary equipment.

The advantages in the use of MVSC are significant. It allows the use of standard commercial products to fulfill an agency's need wherever possible. This is significant in reducing the cost of writing and maintaining specifications, first article testing, and, perhaps most importantly, ease of contracting.

Historically, the government has acknowledged the use of MAS contracting based upon the theory that if a firm makes and sells a significant number of a product to the general public and the sales are from a commercial pricelist, then it is assumed that the firm makes a quality product. If such were not the case, the economic theories of supply and demand would dictate that the firm would go out of business.

The use of MVSC allows each specific agency to determine exactly which item, by brand name and model, will best meet its unique requirements. In addition to the above, it is required that the firm offer its standard commercial warranty (Schroyer). In the past, if a product was defective but still met government specifications, the firm was not required to replace the product (Schroyer). The use of this warranty provision in SCIT is extremely important since the buying agency is assured of the quality of the product.

The use of MVSC also allows for better customer support. In the past, 6FE-CO, for example, could not guarantee the same quality product each and every time the using agency had a requirement. With the use of SCIT, the using agency has more assurances. Since the contractors can make and sell their own specific products instead of meeting a government specification, back-orders and additional costs associated with first article testing and price analysis are avoided. FAR 15.804-3 states:

Exemptions from or waiver of submission of certified cost or pricing data.
(a) General. Except as provided in paragraphs (b) and (c) below, the contracting officer shall not require submission or certification of cost or pricing data when the contracting officer determines that prices are -
(1) Based on adequate price competition (see paragraph (b) below);
(2) Based on established catalog or market prices of commercial items sold in substantial

quantities to the general public (see paragraph (c) below); or
(3) Set by law or regulation (see paragraph (d) below). . . (Federal Acquisition Regulation 15.804-3, p. 246)

Since the items being offered are commercial off-the-shelf items, it seems likely that shorter delivery times are reasonable. In the SCIT program, for example, no new product run is required. This particularly applies to other, more complex items which are planned to be contracted using MVSC. Generally speaking, the more complex the item, the longer it takes to make according to a government specification. If, on the other hand, the vendor is able to make one of their standard items and use it to meet the government's needs we avoid government unique requirements and they can fulfill the government's order in its routine daily operations.

Although the advantages of better products, avoidance of specification risk, better customer support, and shorter time of delivery are significant, there are also some very real pitfalls. The first major danger is lack of vendor interest. If the government attempts to make a MSVC program for a commodity and they are unable to obtain adequate coverage, then the program is doomed for failure (Hegarty). To illustrate, if, using SCIT as an example, DOD has ten basic brands of tools they acquire from ten different contractors, and only two of those contractors submit offers, the proportionate amount of DOD moneys, hence GSA support to DOD, will not be spent under SCIT.

SCIT is a stock program. In anticipation of forthcoming orders, GSA has spent $6 million in the stocking of products (Schroyer). This was done in order to avoid such areas as backorders and non-timely delivery. One of the considerations (in determining how many products to stock) was an expected annual purchase volume. If GSA has grossly over or under estimated the sales volume then they may wind up losing an important customer base.

Another pitfall would be encountered if the program should ever obtain a poor reputation. If, after its inception, things do not run as smoothly as hoped for, and either firms or using agencies cannot obtain what is required from GSA, then there is the very real possibility that GSA will be unable to market the program in the future.

Another major consideration is the potential abuse of agencies in their requisitions. The current mode of contracting starts when the agency sends a requisition to GSA stating specifically which item is required. The agency is required to document their file in an effort to justify why the cheapest item was not procured. While the justification is not a major issue for the SCIT program, it may become an issue for other MVSC contracts. In essence, it can lead to sole-source buys. GSA, the ordering agency, original did not review the justification. In the past, an agency can simply make a requisition for a more expensive item and have an inaccurate justification in their files (Hegarty). This has been rectified by the requisitioning office forwarding a copy of the justification to GSA. If GSA, as the ordering agency, needs further clarification it may then obtain it from the customer agency.

MVSC is questionable in regards to CICA. While it is similar to MAS contracting, it is not one of the five recognized forms of

competitive procedures (Hegarty). While it is not illegal per se, it seems to delve into the gray area of legality. It can be argued that since MSVC is based upon the same principles as MAS contracting, it is indirectly recognized as a competitive procedure.

Another problem with MVSC contracting is the fixed-rate surcharges. In theory, all GSA has to do once a requisition has been received is to cut a delivery order to the vendor/warehouse and the product will be forwarded to the end-user. Since the cost associated with the delivery order is primarily the same for any size order, then one may expect there to be a flat processing fee plus a substantially reduced fee for each tool, instead of a surcharge on the total order. The use of the latter formula would encourage consolidation of requirements as well as a more reasonable savings for higher dollar volume orders (Hegarty).

This system may be used in the future, but it seems too complex for today's use. GSA has difficulty in accurately projecting the total dollar volume of orders received per annum. It is unreasonable to expect them to be able to accurately project the number of individual purchase orders, the dollar volume of each order, and from that to calculate a rate which would support a break-even fiscal year surcharge.

The final complication to consider is price. Historically, competition is a great influence in pricing. SCIT's prices for similar equipment are, surprisingly, higher than those under the normal stock contracts for tools. This was justified based upon the differing terms and conditions, such as warranty and marking, as well as the criteria of award being different. SCIT avoids direct competition and the MAS-type of award criteria (a price equal to or greater than the most favored customer) were used (Schroyer). Due to the different form of contracting, combined with different terms and conditions, the higher prices were found fair and reasonable.

The Automotive Commodity Center has implemented the MVSC program for three areas: fire fighting vehicles (entitled ALF - A Lotta Firetrucks), waste disposal vehicles(entitled TRACY - Trash collection and Recycling equipment Available Commercially for You), and tankers and refueling vehicles (entitled NATE - Now Available Tankers and Equipment servicing vehicles)(Feit). The successful use and implementation of SCIT was the deciding factor in the use of MVSC. In spite of the same basic concept, there are some major differences. Fire fighting vehicles, waste disposal vehicles and tankers and refueling vehicles are items of a very complex nature where tools are, by comparison, simple.

The above programs require an extreme amount of contract administration, technical support, and both vendor and agency interest in order for them maintain their usefulness. Another major difference is the fact that the SCIT program was a Stock based program where fire fighting vehicles, waste disposal vehicles, and tankers and refueling vehicles are purchased when the requisitions are received from the customer agency. The above has resulted in some slightly different clauses than those which appear in the SCIT solicitation or any MAS solicitation.

A final area which has evolved out of the MVSC program is the use of this type of contracting for forklift trucks and off-road

vehicles (Theunissen). GSA's Fort Worth, Texas offices have implemented a program for both forklift trucks and off-road vehicles.

The Automotive Commodity Center originally assisted in the implementation of the forklift truck program by providing technical support in the preparation and initial implementation of the program.

The use of MVSC in the area of complex equipment purchases such as the ALF or TRACY programs has become a very effective contracting approach. ALF and TRACY were implemented in July 1992. Prior to ALF and TRACY

Firetrucks are never generic. Although each truck is based on the same general body/chassis, there are literally thousands of specialized combinations of options and accessories which can be added to meet each agency's individual requirements. On this basis, MVSC contracting seems to be the most promising form of contracting. It will aid GSA in supplying a viable product to the end-user agencies. This logic also applies to refueling vehicles.

Using MVSC contracting in the above situations has significantly reduced contract lead times, delivery time, and cost. This is because GSA in the past, purchased the above equipment on a definite quantity basis (Feit). Each individual requisition must be synopsized, negotiated, and awarded before delivery can take place. This is inefficient with regards to time, as it takes, on the average, two and a half to three years from receipt of requisition to delivery of the final product.

In the past, before MVSC was used in the Automotive Commodity Center, GSA received and fulfilled approximately five requisitions for fire fighting vehicles and five requisitions for waste disposal vehicles. The total number of vehicles per year ranged between five to ten vehicles per annum based upon the above requirements.

From July 1, 1992, the inception of the ALF and TRACY programs, to December 31, 1994, a two and a half year period, GSA has received and processed 165 requisitions for a total of 206 vehicles under ALF and 161 requisitions for 204 vehicles under TRACY.

The dollar value of the orders placed under ALF, over the time period stated, are over $36 million and sales under TRACY exceed $18 million. The surcharge received from the above sales, combined, over said period exceed $850,000.00.

Previously, it was stated that one of the goals of MVSC was to increase customer support as well as to provide products delivered on a timely basis. It was also stated that it was not unusual for vehicles previously purchased under a definite quantity procurement using a federal specification, to take two and a half to three years from requisition receipt to delivery of a vehicle. Of the 206 vehicles ordered under ALF 148 have been delivered. Similarly, of the 204 vehicles ordered under TRACY, 174 have been delivered.

On average, the delivery time under the above programs ranges between six months to one year, dependent upon the particular vehicle being purchased and the contractor cited in the requisition.

The Automotive Commodity Center has, upon occasion, even been able to assist customers when an urgent need occurred. In such instances vehicles have been provided in

a matter of days to weeks. GSA, in such instances, has contacted each contractor to see if any vehicles are currently in production or have just come off of the assembly line where the original customer who ordered it has been unable to fulfill their obligation to buy said vehicle.

If the model produced is under the GSA contract we can then procure the vehicle and provide it in an expedited manner to the customer agency.

Hopefully, this paper has demonstrated the effectiveness of MVSC as an alternative source of customer support for Federal Agencies. The program has exceeded the expectations of GSA in several key areas as well as providing a new way of providing the customer what can best meet his individual needs.
It demonstrates GSA's commitment to the customer as well as to their attitude and belief of procuring better, cheaper, faster, or not at all.

As a final analysis, the use of Multiple Vendor Source Contracting will become more prevalent in the future due to the use of industrial funding in the government's procurement sectors. This form of contracting is designed specifically to address areas which are not adequately being covered by the more conventional and traditional forms of contracting. While there are some difficulties in establishing the contracts, some dangers, including extreme cost risk, may exist. The advantages quickly outweigh the disadvantages. MVSC contracts will become more prevalent in very complex commercial-type equipment where the contracting officer must be in contact with the firms on an almost daily basis. MVSC will become more prevalent not only because GSA is industrially funded, but also because it is an innovative approach to help meet GSA's customers' requirements in what is currently the most inexpensive and cost-effective manner. The program is specifically designed to stream-line the procurement process for unique, but recurring, requirements. The tremendous success of the Pilot Program of MVSC can be attributed to forethought and painstaking thoroughness.

COTS IN SUBMARINE ELECTRONIC WARFARE SYSTEM

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ABSTRACT

The High Probability of Intercept (HPI) Receiver System provides emitter intercept, signal processing, and emitter identification of simple and complex radar emissions throughout the Super High Frequency (SHF) and Extremely High Frequency (EHF) spectrum and will be installed on SSN 688 Class and possibly SSN 21 Class submarines. The HPI makes significant use of Commercial Off-the-Shelf (COTS) items which were repackaged to meet the submarine electronic warfare usage requirements, resulting in a "ruggedized" COTS system. HPI has successfully completed its First Article Qualification Test, which included the submarine operational environments of shock, vibration, airborne and structureborne noise, operating and non-operating temperature, and electromagnetic compatibility. The HPI uses standard Original Equipment Manufacturer (OEM) subassemblies, such as Intel 486-33/66 mother board, Planar, Inc. digital plasma display, Motorola 68020 and 68040 Signal Processor circuit boards, COTS removable hard disk drive, and off-the-shelf microwave components and solid state amplifiers. The HPI design was specifically structured to support survivability and reduce stress on the COTS items. In addition, extensive reliability tracking and quality vendor selection efforts were implemented to ensure that COTS failure problems were quickly identified, analyzed, and remedied by the vendors and that subquality vendors were expeditiously eliminated from the qualified vendors list. Further, Environmental Stress Screening (ESS), reliability burn-in, and reliability growth test programs were implemented to assist in the identification of problem vendors and COTS manufacturing process and component selection deficiencies. HPI is in production and is well liked and easily operated by Fleet operators.

INTRODUCTION

Background. On 29 June 1994, Secretary of Defense William Perry issued a directive to increase access to commercial state-of-the-art technology and promote the development of dual-use commercial and military processes and products in order to expand the industrial base that is capable of meeting defense needs at lower costs. 1/ The use of COTS in military systems needs to be carefully reviewed to ensure that the operational requirements can be achieved within the program's cost and schedule constraints. A significant requirement is the operational use and mission environments, such as shock, vibration, temperature, noise, and electromagnetic compatibility.

Scope. This paper provides an example of how COTS items can be effectively used in a military system by repackaging techniques to meet the submarine electronic warfare usage requirements, resulting in a "ruggedized" COTS system. Other COTS lessons learned are discussed.

COTS APPROACH

The HPI Receiver System covers the SHF and EHF frequency spectrum. The system includes a Radio Frequency (RF) distribution and amplifier unit (RFDU), a receiver processor unit (RPU), and a system control display processor unit (CDPU). The system provides emitter intercept, signal processing and emitter identification of simple and complex radar emissions throughout the SHF/EHF region. Figure 1 provides a picture of the HPI Receiver System.

The SHF/EHF HPI makes considerable use of COTS items. The CDPU uses a standard OEM Intel 486-33/66 mother board with integral processor and RAM memory and standard off-the-shelf Planar, Inc. plasma display. A COTS removable hard disk drive was environmentally mounted in HPI to meet shock and other requirements. The RPU uses two 68020 and one 68040 Motorola CPU Non-Developmental Item (NDI)/COTS circuit boards. The RFDU makes extensive use of off-the-shelf NDI passive microwave components and solid state amplifiers. The HPI signal processing software makes extensive use of previously developed Government software from the Navy's AN/ALR-67 system and the commercially available real time UNIX multi-tasking operating system and utilities. In addition, the signal processor design is an open system architecture which uses a Versatile Module Eurocard (VME) bus and standard OEM card cage to allow for easy expansion of processing and interface capabilities. The processor to controller interface uses a standard IEEE Ethernet bi-directional data link.

In order to meet the stringent qualification and operational requirements imposed by the submarine operating environment for airborne/structureborne noise, operating and non-operating temperature, shock, vibration, and electromagnetic compatibility, the HPI unit designs were specifically structured to support survivability, and where applicable, reduce stress on the COTS items. This is a significant design requirement that affects the COTS reliability and has been demonstrated during the environmental qualification testing. The COTS items that have sufficient design margins for the electrical, mechanical, thermal, and structural design requirements, as shown in design analyses and demonstrated by actual test results, will generally result in a "robust design" that will meet the mission reliability and performance requirements of the system. Sufficient design margins are critical for mission critical items, such as the HPI system which has a radar threat warning requirement, that must exhibit high reliability. High reliability will not only result in achievement of mission success but will also result in significant reductions in corrective maintenance and life cycle operating and support costs. Since military systems operate in hostile environments with extreme temperatures and mechanical stresses, reliability is crucial to the success of the mission or the system's life cycle. 2/

In addition, extensive reliability tracking and quality vendor selection efforts were implemented in HPI to assure that COTS failure problems were quickly identified, analyzed, and remedied by the vendors and that subquality vendors were expeditiously eliminated from the qualified vendors list. Environmental Stress Screening (ESS), reliability burn-in, and reliability growth test programs were also implemented to assist in the identification of infant mortality failure trends and manufacturing process and component selection deficiencies in COTS items.

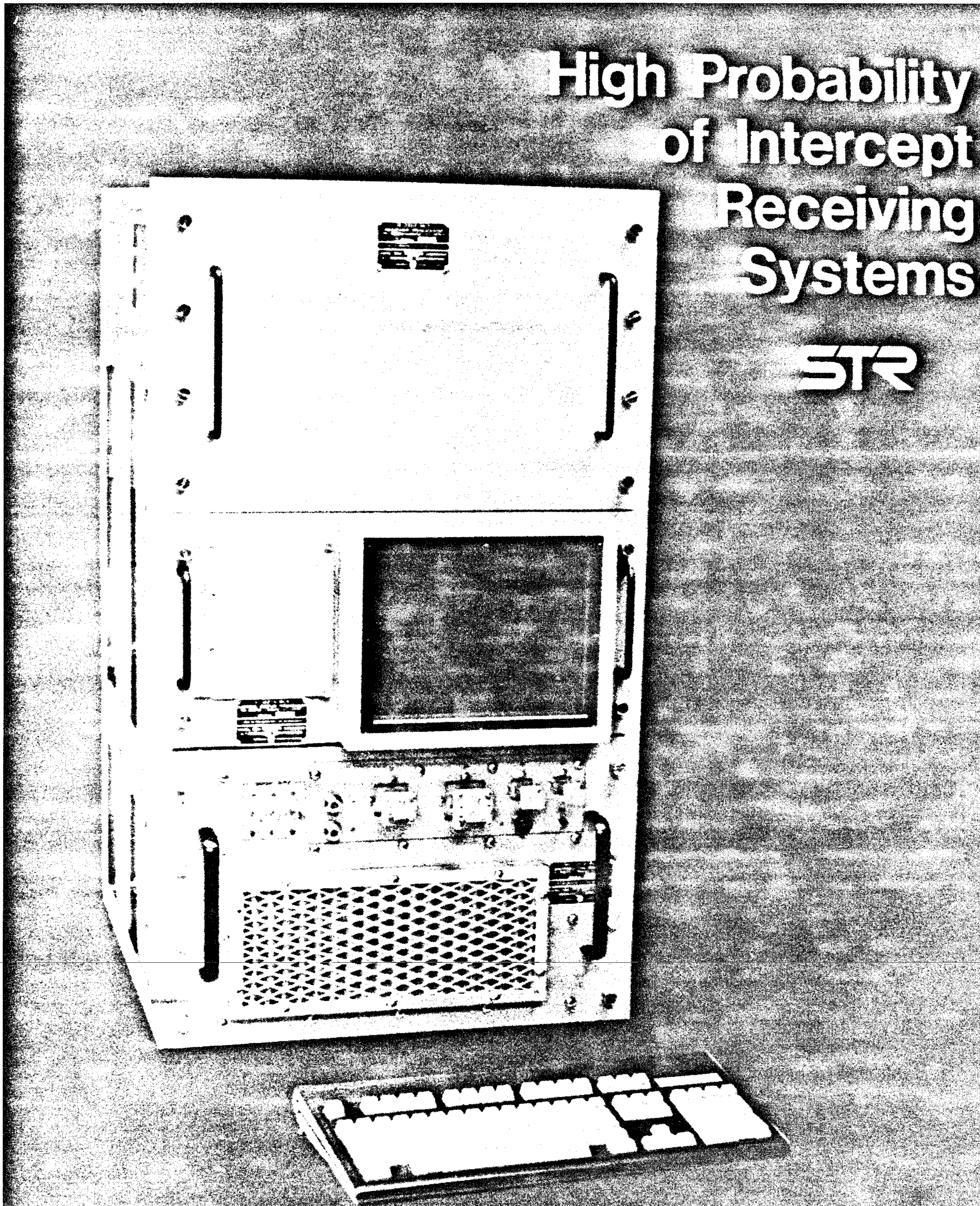

Figure 1. HPI Receiver System

The HPI system design provided for future upgrades of the COTS items which are interchangeable to satisfy the HPI supportability requirements. The supportability of these COTS items will need to be continually addressed as this is a significant issue due to the rapid obsolescence of COTS items. The use of VME backplanes and VME compatible selection of interfaces and designer boards will reduce the operational and supportability impacts caused by component obsolescence, which can be expected in the dynamic COTS industry.

SOLICITATION

The HPI specification was a full performance, competitive, firm fixed-price contract that was tailored to eliminate any unnecessary Military Specification or Standard imposed requirements without sacrifice of submarine operational environmental qualifications. The Government maintained a close working relationship with the contractor to ensure that the Government received the best quality system for the best price. Quality and performance, even to the component level, were emphasized in this procurement. The working relationship, fostered through monthly in-process status and technical reviews between the Government and the contractor, allowed for early identification of problems, effective evaluation of Government and contractor engineering and logistic recommendations, and expeditious resolution of program impacts within the framework of the fixed price contract.

LESSONS LEARNED

The following summarizes the lessons learned:

1. Get operator input. The HPI system was tested by Navy experts from the Fleet, i.e., personnel who would operate the HPI system on a daily basis. By early involvement of the Fleet operators, the design activity was able to identify operational deficiencies prior to deployment.

2. Maintain a working relationship between engineering and logistics disciplines. This helps each specialist understand the "system picture" and facilitates comprehension of technical and logistics interrelations.

3. Use a team approach which involves not only a close working relationship between Government and contractor engineers and logisticians but also other relevant Government activities, e.g., Government depot, In-Service Engineering Agent, installing activities, and Inventory Control Point.

4. Structure the system design to reduce stress on COTS items. High reliability can be achieved in a system with COTS items when the system design is structured to support survivability and reduce stress on the COTS items where applicable. This must be demonstrated during the environmental qualification testing.

5. Maintain close engineering oversight of COTS vendors' quality since vendor manufacturing quality can differ significantly between vendors for the same form, fit and functionally equivalent parts and assemblies.

6. Pay attention to operational Human Machine Interface (HMI) and Human Factors which have a significant, beneficial impact on operational training. In this case, a scheduled two day basic operational training course was reduced to a half day, and a ten day operations and maintenance

training course was reduced to seven days due to good HMI.

7. Plan for future upgrades of COTS items. A system with COTS items must provide for future upgrades of the COTS items which must be interchangeable to satisfy the supportability requirements of the system. The use of VME backplanes and VME compatible interfaces and circuit boards will reduce the impact on the system design performance caused by component obsolescence.

8. Pay careful attention to and streamline the performance specification and documentation requirements which can facilitate the use of COTS in military systems and enable the achievement of stringent performance requirements. The design activity must have highly competent technical and logistics expertise to successfully accomplish streamlining of the requirements.

9. Use the vendor and sub-vendors' technical documentation package to the maximum extent possible. If the vendor's documentation package produces adequate information, or if it can be made complete with minor revisions, then specifying "Navy standard" data item requirements for format compliance or consistency is non-productive.

10. Use an open system architecture design. The use of an open system architecture is an absolute must when extensive use of COTS computer technology is used. With the rapid pace of advancement in the OEM computer industry, the system must be easily upgraded with new commercially available technology products and processes or the system will soon be overcome by obsolete part redesign.

CONCLUSION

The Government-Industry working relationship resulted in a successful First Article Test of the HPI system. It also provided an improvement to the contractor's product line. The HPI system is a system with "ruggedized " COTS items that meets the required form, fit and function of the performance specification. This system is well liked and easily operated by Fleet operators. The stringent environmental design requirements can be achieved by the COTS items by careful attention to the system design architecture that must be structured to support survivability and reduce stress on the COTS items. The COTS design margins for high reliability must be verified in design analyses and demonstrated by actual environmental test results in order to produce a "robust design" that will meet the mission reliability and performance requirements of the system. Close engineering oversight of COTS vendors' quality must be maintained since vendor manufacturing quality can differ significantly between vendors. The use of an open system architecture is critical when COTS computer technology is used to allow for future upgrades with new commercially available products and processes.

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MULTIPLE AWARD REQUIREMENTS CONTRACTING

Mark Werfel

I. ABSTRACT

A new contracting approach for information systems products available in the commercial marketplace is required. Based on a multiple award approach, after an initial competition, a few select firms would be allowed to offer a broad range of products at prices which they set, but would be required to meet contractually established standards or other requirements. These products and prices would be offered in electronic catalogues. Users would be free to select the best value from what is offerred when they review these catalogues, and reflect their satisfaction with these firms, the products they offer, and the support receivedwhen they place additional orders, making past performance more effective than ever before. These improvements apply Government wide, and may also be used for other commercial products when a large business volume, rapid product improvements and turbulent pricing exist.

A. Problem Statement.

The benefits of competitively set prices do not persist after award. Currently, contracts for these products take several years to competitively award, but due to the changing nature of the marketplace (offering rapid technologic improvements and as rapid price reductions), the products offered at award at competitively set prices are normally updated using technology refreshment clause provisions. However, now that pricing is noncompetitive, the prices are not discounted to the extent reflected in the initial award.

The Government accepts the loss of those discounts because of the inordinate amount of time required for and the difficulties associated with introducing a new prime contractor (the National Performance Review cites 4 years for Government vs 13 months for Industry). This condition is well known to both parties, and for that reason, the result is the loss of effective control over a single prime contractor after award including the lack of an effective measure for introducing and pricing new or improved products. In effect, competition's benefits, as currently practiced, only are present for the brief period immediately after contract award (and may not be then, if initial testing or administrative delays defer ordering, in a market which characteristically offers significant and almost constant price drops).

B. Solution Overview.

Instead, the suggestion would make competition effective and persistent, by awarding "Multiple Award Requirements Contracts" (MARCs). As suggested by "Multiple Award", several contractors would be awarded prime MARC contracts, and remain in competition with one another throughout contract life. As suggested by "Requirements Contracts," defined users would have to go to one or more of the awardees for

Please note that the views expressed in this paper are those of the author and do not necessarily reflect the views of the Department of the Army.

defined products (the Approach section describes this in detail).

Briefly the process would work like this:

Periodically, MARC contractors would unilaterally update their offerings, striving for business on that and on a past performance basis.

Due to the commercial nature of these products, more reliance would be placed on contractors, and less Government involvement and oversight would be required.

MARC contractors would be responsible for the products they provide whether they produce them or their vendors do; and for overall customer support and satisfaction. Contractors failing to support users would simply not get future orders, because users would issue new orders to the other MARC contractors (and contracting personnel would ensure appropriate action was taken on the existing problem orders).

Users would be accountable for the products they select, and the prices, because their access to a more competitive marketplace would be direct and unrestricted.

Electronic media would be used to accomplish contract updates instead of the less productive and highly people intensive mechanics currently used.

Expectating that MARC contractors would offer better deals to the Government than otherwise available, if disappointed, users would not be absolutely required to go to them, but would identify when and why they did not.

II. BACKGROUND

A. Current requirements contract process. Currently, these may be competed, promising the successful bidder all of the work of an identified type of business that an identified set of users will place over a defined period. Source selection criteria would normally include factors which measure the cost and also the value to the Government of various proposed solutions. Associated terms and conditions are generally set by the Government in the solicitation, and generally apply to all bidders. Once awarded, work is ordered as established by that process. The awardee has the right to sue the Government for breach if orders are placed elsewhere, even if a better deal becomes available. However, if the requirements contractor's prices become higher than market prices without additional benefit, they are no longer fair and reasonable, and the Government is not bound by its terms.

B. Types of Markets. Government contracting organizations essentially operate in three types of markets:

1. the major systems environment. This is highly structured on both the Industry and Government side, with specific business units established to support Government customers and special rules (e.g., cost accounting standards) which apply only to them. Due to the unique nature and use of these products, commercial market forces and comparisons are irrelevant. Military or

Government unique information systems are included here.

2. general purpose commercial products. The Government, using small purchase procedures, the Federal Supply Schedule or IFB procedures for large quantity buys of commercial and stable products and pricing, generally performs well.

3. commercial information systems. While not generally recognized as a separate market, it should be distinguished from the first two types due to the evolutionary and revolutionary ongoing changes in price and technology, and to the large dollar volume of Federal purchases involved. While the Federal Government does not dominate this market, and may represent less than 10 per cent of it overall, individual contracts in this market are expected to exceed $50 million (and often more); so certain economies would be expected to accrue to the Government customer and also to provide other market influence/leverage. This suggestion only discusses this market, but as these products may be acquired by the Government here and GFE'd (provided as Government furnished equipment) to systems contracts to prime contractors when the Government is the end user, it addresses this potential use as well.

C. Current Process Shortcomings Identified by National Leaders. Government acquisition of information products are not as effective as they could be, as discussed in Mr Kelman's "Procurement and Public Management (Atch 2):"

1. Due to falling prices and rapid technologic change/improvement, prices successfully bid in response to RFPs are largely irrelevant (p. 30) given either:

a) products other than those in the original award, which are noncompetitively added after award under technology refreshment clauses, and priced in a noncompetitive environment (the National Performance Review complains of hopefully occasional price gouging), predominate what is actually delivered, or

b) products that were state of the art (or at least current) when awarded/negotiated, are obsolete when delivered (according to the National Performance Review), or

c) even without product change, prices for those products in the successful proposal often drop sharply in the commercial market place. Accordingly, savings obtained reflect the time taken to make an award, as well as competition. A prompt award represents a financial risk to the awardee, who might seek procedural or actual delivery delays to get well; a situation which may have occurred. This may be why the National Performance Review cites a "286 computer offered the Government at a 486 price."

This questions the value obtained by the competition process for these products. Certainly, the competitive process costs time and money, for both Government and Industry; so there should be a corresponding benefit. To

the extent there is not, a new process is required to obtain it.

2. Due to the difficulty of forecasting future requirements and available funding, as well as market changes that are not forecast, product mix and deliveries reflected for proposal evaluation may not be reflective of that actually ordered (pp. 30-1). While this may not be possible to overcome as a shortcoming, and represents a methodology that applies to all offerors so that there is no competitive advantage to any firm, it is nonetheless an issue which calls into question the merit of evaluating a specific proposed product solution as a basis for award. Instead, such other as factors as realistically evaluated past performance, in terms of supporting customers and meeting crises, could therefore be much more valuable.

3. Past performance, as a source selection criterion, may not be as effective as it could be due to the nature of the current process (pp. 41-53). Personal history can not be factored in and, typically, the offeror is asked to provide a listing of references, and can be expected to make a self serving selection. Also, performance reports are by their nature subjective, and present other problems, such as their currency and relevancy, that may not be sustained if the source selection is sensitive to it. As a result, scores for this factor are generally the same. Mr Kelman, from a common sense perspective, argues this is perhaps the most valuable criterion and is used more extensively in industry; and the Government not using it is a major failure of the current process.

4. There is little effective control over the contractor, given the prospect of a two year period as a minimum to award a new contract (p. 54).

5. Industry's approach to source selection is more flexible, offering the opportunity to obtain and utilize information up to award. Further, it continues into the performance period, where users learn more about what they want from what they use -- how features can become utilized as previously unnoticed benefits (pp. 57-8). In fact, Government acquisitions are often grand design projects that lay out too many details in advance (p. 88), particularly in a world and in a market place that changes greatly and frequently (p. 89).

6. Long term business relationships are difficult to establish, given the Government's inability to effectively utilize or recognize past performance. As a result, good ideas that could be offered to the Government during contract performance may be withheld, so they can be used by that firm in future competitions. If offered earlier, the contractor would not be rewarded for his ingenuity, but that information would be generally released to interested US persons (pp. 64-6, 74). In Industry, little documentation is required or delays encountered, and high quality performance provided, simply because vendors know their customer will tie future awards to current performance (p. 68).

7. Site and program specific knowledge can be developed, with benefit to both parties, over a long term relationship; and additional benefit from informal exchange of

information between the parties' personnel and from capital investments made when justified by those long term relationships (pp. 69-70).

8. Public officials do not have the discretion to exercise judgement and common sense in the sense of what information systems to buy or how to use them. By this, DOD should consider the military user's need for flexibility and good judgement, rather than a contracting process that does not provide it (p. 90) (with comparable considerations by other Departments for their users).

III. PRINCIPLES. These correlate with Vice President Gore's National Performance Review.

A. Cut Red Tape. Program Management, contract management, legal and quality assurance time, effort and personnel, as well as now unneeded documents, would be substantially reduced through use of electronic catalogues, ordering and payment.

B. Put Customers First. Prime contractors, once selected, will be expected to support customers professionally in every sense. If not, a mechanism would be in place to replace one or more of them. In the interim, orders would be written against the other, existing MARC primes, continuing effective competition. In this manner, poor firms or ones that become so would be effectively excluded from future work, which would be diverted to current and future MARC primes; and contractual provisions would still require them to fix already delivered products.

C. Empower Employees. Users will be able to freely select from the catalogues MARC primes present without unnecessary interference or delay from administrative personnel. Similarly, the MARC primes will be empowered to offer the most attractive *products and prices without administrative delay, such as for the negotiations and modification preparation time now required by technology refreshment clauses. In military terms, we expect our warriors to achieve their objectives with the available resources. We have the good fortune to possess warriors with the attributes (flexibility, independence, good judgement (and so forth) to prevail in war. Military users selecting from competing MARC catalogues would be empowered to select the most competitive products and then prevail in a business sense as well.

D. Go Back To Basics. With the flexibility, ease of use and accountability thus obtained, from the standpoint of both the Industry and Government partners, the trust deficit would be closed and efficiencies obtained. Users would clearly see results, and adjust accordingly without intermediaries confusing issues, as would MARC contractor senior managers to the extent improvement is required from their standpoint. Gamesmanship would be eliminated, with any "special" or "frill" requirements from non-user (third party) Government sources accommodated, but priced separately. Actions taken would not be "by the book," but only what makes sense to users who would then have the flexibility to make the decisions they consider appropriate; and whose superiors could then solely hold them accountable for the outcomes. Due to these improvements and those in the "Cut Red

Tape" paragraph, internal Government organizations could also be simplified.

IV. APPROACH:

"Multiple Acquisition Requirements Contracts" (MARCs), are called "requirements contracts" because user requirements within each sector must normally be satisfied against one or more of the set of MARC contracts, similar to the current case if a single requirements contract was issued. They are termed "multiple" because this approach is modified by a Government right to go to any or all of the prime contracts in the MARC set. If a user determined no firm in their MARC set could match or improve on those other available methods, they would not be bound to do something dumb (as currently, another source could be justified because the price is not fair and reasonable) but could accept the better offer. Also, they would briefly document this situation, and send a copy to the MARC set's Government contracting officer for management action.

The overall information systems market could be divided into sectors, reflecting different user types (e.g., office automation, workstations, conference room/auditoria). If deemed to be unwieldy, a different division might be preferable (by Agency, Command or by geographic area). Rather than these contracts being a grand design, all things to all users, and possibly not being truly responsive to anyone, another approach would be to define discrete user groups so the MARC prime contractors would be more focused. Of course, the cost (e.g., administrative and lower business volume) would be compared with the benefit (e.g., more focused approach, more tailored products); and the size or shape of the user group determined accordingly.

A. Terminology. The suggested approach envisions an initial competition to establish groupings (or "sets") of two or more (e.g., three) prime contractors; each MARC set serving a unique user type, (or "user group)." There would be one MARC set supporting each market sector.

B. General. Each set will compete for work on the basis of best value, and will be able to communicate with users without artificial barriers, and utilize electronic tools to do so. The users are empowered to go to whichever firm they chose to in their set, utilize other firms in the set as circumstances warrant, optimize best value offerred and be accountible for results more than ever before. Similarly, the prime contractors comprising each set would freely choose the range of vendors, products and services -- and the prices -- they would like to offer the users; duly noting the need to be competitive.

1. Awards. Three (or so, depending on volume of business expected, the nature of the vendor base and the characteristics of the user group) prime contracts would be competitively awarded to support identified users. Either no or a small volume of business would be associated with the award. Each prime contractor would publish a priced list of goods and services (see "updates") from which orders could be placed by authorized users without further competition (similar to Indefinite Delivery contracts).

Consideration to the prime contractors in the set would be the Government's promise to fill requirements from the user group by orders issued to one or more of those firms. Consideration to the Government would be the expectation those firms would offer better business deals through this process than otherwise available.

2. Catalogues. The prime contractors within each set would periodically and unilaterally establish listings ("catalogues") of products and prices from which the user selection is freely made. This would be done electronically, such as by bulletin board or by a data base, minimizing administrative effort and delay (also, see "updates"); and also tie to ordering and payment functions. The users could select products or services from any or all of the current catalogues offered.

3. Updates. Periodically, perhaps bimonthly, and simultaneously, each prime contractor would update their catalogue, in new "offering periods;" thereby incorporating new or updated products and pricing as they would like without negotiations.

The changes would all be published on the same date, and be effective on the same (possibly a different) date. The updates would periodically occur, with the timing dependent on the conditions in each given sector, balancing beneficial extent of the price/technology change in the marketplace with the user sector's cost and difficulties associated with implementing each change.

4. Scope. Product and services updates must be appropriate for the broadly defined requirements of the users. For example, mainframe computers might not be appropriate for office automation users, but new generations of personal computers and normally associated products, while new, would be -- while the scope would now really be defined as and by the market sector. To restate the point, the scope might be the current commercial state of the art for office automation, and it must be noted that, over time, leading or esoteric technology would be introduced into the commercial market place, and therefore enter within the contract scope. However, these products must always be commercially available.

Negotiations would not be required in conjunction with these changes, due to the commercial nature of the products, the responsibility expected of the MARC prime contractors and the essential driving nature of competition in this environment, rather than its appearance. Instead of relying on negotiations, the linkage with the marketplace would ensure value to users. If noncompetitive primes existed, they would not likely get business until the next offering period, at which time they could offer a more competitive product/price listing, as would their competitors. That firm's need to recover their management cost would be unsatisfied, due to the low ordering rate -- and the prospect of a loss contract would mitigate against their initially competing or to their willing removal when faced with more competitive firms (or to their unwilling removal or lapse under the contract's terms).

5. Competition. The basis for selection is discussed in the "source selection" paragraph. Once the prime contracts were in

place, they would essentially be competing for work against one another by offering best value (better products, delivery or price, and by their business relationships with users). Users would migrate to the best firms, and away from those they were dissatisfied with, by simply placing orders, without any requirement for justifying their doing so. Administrative procedures would be in place, as currently, if contractual remedies are required on ordered items. Once awarded, given competition would be essentially continuous, the MARC contracts need not have a fixed termination date, but new prime contractors would be added as needed (e.g., to replace poor ones, to provide added capacity, to exert additional competitive pressure).

The commercial marketplace offers potentially higher profit margins than Government negotiators would allow, but cost and pricing data has always been difficult to obtain or verify. The Government need not obtain this data if it can obtain the benefit of it, lower price and superior products, by the use of this technique. Again, that benefit may not be obtained if, for example, mega buy/IDIQ contracts could not obtain prices that were significantly lower than that available commercially or on GSA schedules.

6. Source selection. I will discuss why source selection should not be made only on the basis of a proposed solution, and suggest a new approach to source selection criteria.

Typically, sources are currently selected on the basis of proposed solutions to the situation described in the solicitation. Due to the difficulty of forecasting actual conditions (as described in Kelman's book), and to the certainty of radical change in the information products marketplace, it is problematic whether this approach is practical, relevant or obtains the best result. However, it is clear that, while circumstances change, the ability to provide customer support and to engender positive business relationships are desirable -- and a firm's process of doing so, and results obtained, may be more relevant than a forecast approach to a hypothetical scenario.

In the current political and economic environment, the ability to identify and utilize information systems and products in imaginative as well as productive ways and to cope with change is critical, and can be documented. Offerors should describe how well they have done so.

A source selection factor for proposed business mechanisms to be used to facilitate instant contract and program management, to facilitate user decision making or to manage orders during contract performance, such as use of Electronic Data Interchange, should be considered.

Offerors that act as integrators would be expected to have broad market knowledge of current and future trends, technologies and products; and expend significant costs for that capability, supporting both current customers and that firm's competitiveness for future work. Proposals could therefore allow, but not require, offerors to share that knowledge with selected Government managers. The information would be used for planning purposes, respecting the MARC contractor's proprietary interest, and Government

personnel, as with other proprietary information, would be liable for prosecution if they failed to protect it (as currently); or transferred it to other firms (e.g., technical leveling). Only the contractor's presentation costs would be recognized by the Government, because that information and the cost of collecting it is already incurred for their business purposes, but award fee may also be paid when significantly valuable.

7. Administration. No negotiations and less bid and proposal effort (due to the long term nature of the contracts) would be required, with concommitant savings for both parties, which due to competition would be reflected in lower contract prices.

The Government would not be locked in if no MARC prime contractor offerred fair and reasonable prices. In that case, a simple justification would document purchases not placed under MARC procedures, and would be required due to the Government's consideration originally. In the unlikely event this occurs, a copy of the filed document would be sent by the ordering organization to the MARC contracting officer for review and possible management action.

8. Quality Assurance (QA). Due to the high reliability of commercial information products today, testing and QA should not be required. Each MARC prime contractor and its lower tier suppliers will be responsible for satisfying customers, and more extensive Government quality assurance would be unwarranted, unless desired by a user on a fee for service basis. Each prime would be responsible for any contractual warranties desired by the users, and vendors'(suppliers to primes) standard commercial warranties in excess of contractual requirements would flow to the Government. As stated elsewhere, continuing user problems with any prime would result in present day type contractual action on existing orders as well as naturally shifting future orders away from poor primes to the ones that satisfy users best. If extended warranties are desired by users, they would be made available/required and an additional charge could be established for them.

9. Contract structure. Separate contract line items would be established for baseline items and for additional support. For example, computers could be ordered on a no frills basis (drop ship from manufacturer to be installed by Government or local contract support personnel), minimal service (in metropolitan areas, use of a credit card for walk-in service at a firm's warehouse or their vendor's) or full service basis (the prime installs products at the Government site). Alternatively, rather than contracts which serve the full range of customers, separate contracts only for full service MPKs and others only for limited service MPKs could be issued if deemed more workable. As stated elsewhere, associated upgrades, warranties or related services could be separately priced. Also, multiple product groupings (sometimes called configurations) for a standard work unit could be offered, which typically present savings.

10. Program Management. Government employee use could be minimized, with only direct and supervisory employees required for contract operations. The approach would totally be on a value added, fee for

service basis, and not subject to normal administrative controls.

Administrative effort could be totally paid for by the requestor (e.g., Freedom of Information Act requests would be satisfied by program support employees whose salaries would be totally paid by associated charges, and perhaps contracted out to an associated administrative arm as now offerred by the US Department of Commerce's National Technical Information Service). Similarly, users or other organizations such as their headquarters requiring reports would be expected to directly pay for them, with appropriate accounts established in advance for them. This could be difficult for the Government to accept, but visibility of operational costs and accountability for other ("overhead" and non value added) effort would be required if we would demonstrate the value of this practice and expect competitive practices.

An amount would be added to each order, perhaps as a percentage of the order value, to fund the employees's salaries and overhead costs. An additional amount to be levied, without interchange with the first pool, to incentivize the primes to be determined and described by the users.

User group boundaries must be considered carefully. Small Agencies or other, larger Agencies with low volumes of orders at widely distributed sites may not warrant inclusion to the extent they would be detrimental. This would be the case if the administrative burden of carrying them would significantly reduce the business deal that would be offered by primes otherwise to large volume, well managed users.

The MARC contracts are in effect a tool, not a program. Accordingly, no separate program management function would be required. Controls would be as currently established for funding or information systems oversight. The contracting organization would satisfy any additional oversight functions required. Each sector would be separately managed by the contracting organization responsible for it, with periodic user meetings and subsequent Government/prime contractor meetings as required. Use of MARC would satisfy competition requirements, and the volume of purchases expected should save users time and resources accordingly.

Government information that is currently acquisition sensitive could now be shared (between the Government and each contractor, but not between contractors), given the MARC contract's long term nature reduces the need for annual or frequent competitions and the need for categorization of that information as such. In turn, sharing information freely has a beneficial effect, and fosters business relationships that become more of a partnership. For example, we may expect that, with shared information, planning and therefore outcomes will improve.

11. Comparison with other techniques. Indefinite delivery contracts, as described in Dr Kelman's book, are not sufficiently flexible, have high overhead costs, and do not offer the best value to customers.

Bulletin boards have been successfully used to overcome the problems associated with the prior contract type, but require periodic listings of new requirements and are more manpower intensive than the MARC approach; offering administrative cost savings in addition to heightened customer satisfaction. Also, due to the high volume of work, economies of scale would be experienced versus the short term and limited value of the many small competitions that characterize the bulletin board approach.

GSA schedules. Currently, these schedules are awarded for predetermined periods of time, with set products and pricing, and with lower levels of work. Also, they require a significant effort on the part of Industry and the Government to negotiate and to maintain. Accordingly, the MARC approach is more flexible, more likely to promptly recognize price reductions and product improvements, and to have a lower administrative cost for both parties.

12. Standards. Government standards have been sought and often published, with mixed results. Well intended standards offer theoretic commonality and connectivity advantages; but it has been argued that they also have a higher initial cost, users are unwilling to pay for the higher cost they bear in practice and their intent is now achieved in open systems as driven by competitive pressure.

The essential flexibility of the MARC approach will afford the user access to market driven forces and results -- including the flexibility to be aware of and react to products that become more or less attractive due the interaction of evolving standards in a commercial marketplace -- and then the user will be responsible for the decision made in accordance with any direction imposed by his management process.

Please note that the views expressed in this paper are those of the author and do not necessarily reflect the views of the Department of the Army.

CONTRACTING
AND SUBCONTRACTING

DEFINITIZING CHANGE ORDERS

REVOLUTIONARY THINKING

JAMES H. GILL

ABSTRACT

Conventional wisdom with regard to change order definitization states that it is in the government's interest to negotiate and definitize change orders at the earliest possible time. On incentive contracts, traditional thought teaches us that the contractor will work efficiently to minimize cost incurrence thereby saving money for the government (on the share line).

While this is often true when dealing with responsible contractors, it is predicated upon an assumption of a negotiated fair and reasonable price. I will postulate that it can be demonstrated that there are contractors for whom this behavior is tantamount to "giving away the farm". There are some contractors for whom, for a variety of reasons, it is more beneficial to the government to delay negotiations until most, if not all, of the effort is complete. The resultant actuals can translate into substantial savings to the government when compared to negotiated settlements which comply with the DoD recommended schedule (180 days or less).

This article will provide factual data which will demonstrate conclusively the merit in negotiating actuals in certain instances. While limiting the scope of the recommendation by the nature of the acquisition and the performance of the contractor, a general exception to the traditional change order definitization process is appropriate.

I will analyze the results of data on change activity with two contractors fitting the appropriate profile to show the savings realized through this technique. While I recognize that this approach is subject to significant criticism, it reflects the real world and the associated difficulties in government/contractor relations.

INTRODUCTION

Undefinitized Contract Actions or UCA's exist because it is an imperfect world and there is not always time to do things the "right" way. Conditions often conspire to force award of a contract or change order in an abbreviated time period due to schedule constraints. Under these circumstances conventional wisdom would have us maximize effort to definitize these efforts quickly to avoid the "blank check" syndrome. Once authorization to proceed with an effort has been provided to a contractor, he must be incentivized to control costs in order to preclude him from running up a large bill of "actuals" and presenting them to the government for payment and inclusion into the contract target. These actuals are extremely difficult (if not impossible) to negotiate away.

Traditional thinking would have us believe that risk is mitigated by early negotiation of a "target" cost against which the contractor will more efficiently manage the effort if he is to maximize profit. Incentive contracting normally has at its essence the principle that contractors are motivated primarily by profit and will not incur unnecessary costs which they would

then have to share with the government under the incentive arrangement.

While this is normally true, there are exceptions such as the maintenance of a workforce during lag periods when a contractor is between programs. During the current downsizing of defense related industries this has become more of a problem than in prior years when contractors were expanding to meet the increases in the Defense budgets.

We will accept the premise that contractors normally are motivated primarily by profit and will seek to maximize it. Is it not then sensible to negotiate a target cost as early as possible in order to put the onus on the contractor to minimize costs?

The answer to this question is the traditional Defense Systems Management College (DSMC) answer, it depends. It depends upon the government's ability to ensure that the target cost is fair and reasonable. If the negotiated target cost is unreasonably high, then the fact that the target cost was negotiated in a timely manner is of minimal relevance, as is the contractor's eventual success in underrunning the target.

Change Orders by definition involve effort that is time sensitive, i.e. if the effort was not critical, a supplemental agreement would be accomplished. Proposals for this effort normally rely heavily upon engineering estimates rather than actual history. Contractors normally inflate these estimates toward the high end (estimates for developmental work will normally have a broad range of variability).

Most contractors will have some negotiation flexibility within their initial proposal. Some contractors are more flexible than others with regard to their willingness to move from their initial proposal. In a perfect world, both parties would reach an agreement on a target cost that reflected a shared risk that the contractor would realize a fair profit if they perform the effort competently.

Unfortunately, there are extraneous factors that complicate the process. One of these factors is the contract type (i.e. fixed price incentive) and its relationship to a ceiling price. If a change order is issued to a contract in which the contractor is facing an over ceiling position, i.e. one in which he is assuming a share ratio of 0/100%, it is more than likely that he will attempt to use the change order to recover some of the ceiling dollars. In this environment, the contractor is less interested in profit than in ceiling price. The ceiling price is a direct factor of target cost, therefore, the contractor will attempt to maximize the target cost adjustment for the change order. In this environment it is difficult for the government to convince the contractor that his proposed cost is "unreasonably" high.

Other factors may also come into play in a contractors seeming intransigence with regard to target cost. There may be an extremely adversarial relationship that has resulted from previous problems regarding scope of contract. Some program managers assume all effort is included in developmental contracts (this may be a result of program budget problems) and resists issuing changes to the contract. Conversely, some contractors read statement of works extremely literally and attempt to change order contracts to death. Developmental contracts normally require some ambiguity in their SOW's due to the nature of the effort. It is this ambiguity that makes a cost-plus contract a more reasonable vehicle for a developmental effort.

If the change order is made to a cost-plus contract, the risk factor is not normally the impetus for a contractor to hold to an exorbitant estimated cost. On a cost type of contract the fixed fee, award fee or incentive fee is a factor of the estimated cost.

In those instances in which a contractor has "bought in" (i.e. accepted an extremely optimistic estimated cost for the basic contract), the motivation may be to recoup some additional fee that was not realized with the award of the basic contract. Some contractors view the changes clause as the perfect vehicle by which they are able to get well - a Health Plan that even Mrs Clinton would admire.

When there is a problem with the negotiation of a fair and reasonable price for a change order, it is important for government management to use discretion in the constraints associated with the time guidelines imposed upon the negotiation team for the definitization of contract actions. In certain cases it may be prudent to allow the effort to go to completion before it is definitized. This obviously will not be a preferred course of action, however it is preferable to imposing a unilateral price upon the contractor or arbitrarily throwing money at the contractor merely for settlement purposes.

The practice of negotiating actuals is certainly not the policy of DoD contracting offices, however there are some benefits to be realized from this course of action. First, it allows the actual costs to be used as a basis for profit. Obviously, this is not a recommended practice in those cases where a contractor has the flexibility to run up enormous costs outside the view of the government representatives (ACO, DPRO Quality Inspectors, DCAA, Program Managers etc.).

If the effort is relatively straightforward, and the government oversight continues to be effective, then there will be little opportunity for abuse of this nature. It should not be necessary to wait for the entire effort to be completed, merely enough work to validate the government's technical estimate. Only in rare cases would actuals to completion be required to reach agreement. Second, the adjustment to ceiling price, for the change order effort, will be minimized if the risk has been reduced by incorporating actual costs. It would certainly not be necessary to give the contractor the same ceiling price rate if the risk of overrun has been mitigated by allowing actuals to be incurred.

Third, with the government assuming much of the risk, the profit rate that the contractor receives will be significantly reduced.

This is all well and good in theory, but what are the practical applications of this in the real world? I believe that it can be demonstrated from actual case histories that a significant reduction was realized through the use of this approach. It must be stated again, that this is an abnormal situation that is not to be confused with the norm, i.e. definitization within 180 days or less.

BODY

Two contractors having 3 contracts with the government were selected that met the parameters identified above, i.e. they were over ceiling or they had a history of intransigence in negotiations with the government. For the purpose of this paper it is not necessary to identify these contractors other than to indicate the rationale for including them as

candidates for use of actuals in definitizing change orders.

The underlying premise behind this research is to assert that assessing timelines to definitization of change orders, i.e. 180 days, should be tempered with judgement and should therefore be situational. If management is to give contracting officers the flexibility to decide appropriate courses of action, then this flexibility should include disregarding arbitrary timelines whenever it is deemed appropriate.

The two contractors utilized for this study fit the profile in two ways. First, they are historically inclined toward adversarial behavior in contract negotiations. They tend to assume a somewhat arrogant attitude in that they presume that they know what is best for the customer.

Further, they have both been in negative financial situations, both receiving substantial pressure from their corporate headquarters to improve their cash flow and their financial position on their respective programs.

The first contract was for the development of a guidance system. The contractor was initially a relatively small R&D company who had little experience in the actual production of hardware. The government encouraged this contractor to compete for a large development contract with a concurrent production effort to follow. The contractor anticipated a large return on investment to be realized during the follow-on production contracts.

The government sought to broaden the industrial base by bringing on board a potential competitor for future guidance work. While the program was of a fairly large dollar value ($300 million) the organization issuing the contract anticipated several other large dollar awards in the future.

This contract was awarded during the build-up of the defense department during the Reagan administration. Some contractors were "buying in" with the intent to recoup profits during subsequent production buys. Many contractors put themselves into extremely bad financial conditions due to the expectation that they could not lose business to competitors. The risk was compounded by the government's advocacy of fixed-price research and development contracts, many of which were awarded with a high potential for going over ceiling.

Contractors may also have convinced themselves that they merely had to break even in order to place themselves in a favorable competitive advantage for future business. Some may also have hoped to drive out potential competition for the anticipated contracts downstream.

Early in the initial stages of production on the guidance system, it became apparent that this contractor did not realize the difficulties associated with the start up of a production line. It was also evident that the contractor did not have adequate mid-level managers that are critical to the management of an effort of this magnitude.

The government program office had other issues that would subsequently impact the contractor. The Initial Operating Capability (IOC) was critical to the Service. Promises had been made to the Congress which needed to be kept. The Service could not field the system without this guidance system. The program team adopted a hands on approach to solving the contractor's problems.

The contractor discovered, subsequent to contract award, that the defense buildup would not happen in

accordance with the five year plan. Due to Congressional direction, a significantly smaller quantity of guidance systems would be required. This would have a substantial impact upon the potential profits that would be available. Further, due to the disintegration of the Soviet Union, the Service would be seeing a sizeable reduction in its funding and a good portion of this reduction would impact the guidance business.

In this environment, the contractor looked for various options to recover their financial position on the fixed-price contract. One of these options was to file claims for effort deemed out of scope on the production contract and shift those costs to a cost plus development contract. A second approach would be to get well through changes, ECP's etc.

The government contributed to the opportunities available to the contractor by making changes which effectively opened the door to the contractor in the form of proposal opportunities. Most development and production contracts have numerous changes to them during the course of performance. The negotiation of these changes proved extremely difficult as the contractor appeared inflexible and somewhat arbitrary in his justification for the cost breakdown of the requirements.

During this period, there were numerous changes that were added to the contract. The government was focusing most of its attention on the matter of recovering schedule. A good amount of resources were invested in assisting the contractor to fulfill his contract schedule with a quality product. The contractor was required to incorporate several pieces of government furnished property in the performance of the contract. The contractor alleged that the GFP was defective or late in his attempt to recoup both cost and schedule.

During the factfinding part of the negotiation process for these change orders the contractor was reticent to provide traceability into his proposal methodology, frequently changing the rationale for the inflated number of hours proposed. There were numerous meetings between the government team and the contractor attempting to reconcile the substantial differences between estimates.

As a practical matter, some organizations do not believe in entering into negotiations if there is a difference of greater than 10% between the government's estimate of the number if hours required to perform the effort and that of the contractor's updated proposal. The net impact of this approach is to prolong the factfinding process.

There were numerous change orders that did not meet this standard and were referred back to factfinding in an attempt to get the sides to come closer together. Finally, management interceded on several instances, having both teams present their rationale to the respective management groups. Management, having escalated their involvement in the process, would then discover that the problem was not with the respective teams or individuals. The problem was one of risk assumption and ceiling adjustment.

When management's involvement was ultimately unsuccessful, a brief sampling of the efforts that had substantially been completed indicated that the government was realizing a sizeable reduction based upon actual costs incurred. The costs actually incurred and billed for these efforts was less than the government's estimate based upon the contractor's proposal. The government ultimately realized a

lower target cost, target profit and ceiling price than they would have realized if the contractor had merely accepted the government's initial objective.

There may be several reasons for this fact. First, both parties may not have understood the effort well enough. The contractor factored in many contingencies that might not have come true, but which a prudent risk manager could not afford to overlook, especially in an fixed-price environment. Second, and most probable, the contractor may have been attempting to recover some of the costs that had fallen into the over-ceiling amount. It is not unreasonable that the contractor was anxious to get back to a position wherein he would be sharing costs with the government. Nothing focuses senior level management's attention more quickly than the need to use profit to pay for costs incurred. The quickest way for a contractor to receive a bonus is to move costs into the sharing arrangement and this can be accomplished by increasing target cost and ceiling price.

Having identified the problem, what alternatives were available to the government? The contracting officer could issue a unilateral modification which would be subject to the "disputes" procedures and could result in a request for equitable adjustment or claim. In these instances it is unlikely that this would happen because as a rule the ultimate adjustment for costs incurred would be less than the government's objective which would be the basis for the unilateral. Claims can create a significant drain on resources as they require a good deal of work in processing them through the Board/Court.

The government can also reduce the ceiling price (and profit rate) of the eventual supplemental agreement due to the reduced risk associated with the use of actuals. With this approach the contractor must, eventually come to realize that he will be the loser if he does not negotiate prior to the completion of the effort. At least that's the theory.

For example, a contract may have a ceiling price rate of 120%. This percentage is applied against the target cost to develop the ceiling price. If the change effort is similar in nature to the basic contract, it is reasonable to apply the 120% against the target cost of the change order. If actuals are used as the target cost, there is no justification for increasing the contract ceiling price due to the relative lack of risk associated with the change order effort. The increase to the contract ceiling price would most likely be the target price (target cost plus target profit).

This particular contractor did eventually come to realize the error of his ways however he was not successful in recouping near as many ceiling dollars as he would have had he negotiated in a timely manner.

The second example of an appropriate utilization of actual costs for the definitization of change orders occurred during the current time period on a contract for a major modification to a fielded piece of equipment. The value of this contract was in excess of $100M and this was a fixed price development contract. The use of a fixed price was deemed reasonable for this effort due to the off-the-shelf nature of the acquisition. (The contract was initially awarded prior to the revised policy on fixed price development contracts).

As the development progressed, two things became apparent; first, there

was a significant amount of software development associated with the effort. Second, and more important, the requirements were reduced substantially, at least in terms of future potential.

These facts are relevant in light of the fact that the contractor initially was awarded the development contract with what the government believed was a low estimate for completion of the development program. The production contract was issued concurrently with the ongoing development contract and was a sole source fixed price incentive contract. There are indications that the contractor bid on the development contract in part to get his "foot in the door" for future Air Force business.

It is the contention of this paper that this contractor should be treated situationally, i.e. the development contract is over-ceiling and negotiations for changes on this contract should be significantly different from those on the production contract. The proposals from the contractor on the development contract consistently appeared to be inflated, while no such problem existed on the production contract. Estimates on the production contract were within the norm for negotiation purposes. This could perhaps be explained by the fact that the production contract was in a significant underrun situation while the development contract was over ceiling.

The analysis of the rationale for the hours proposed invariably determined an unreasonableness that was further compounded by an unwillingness to negotiate, i.e. little flexibility in their position. Why was this? It seems likely that this was an attempt to regain ceiling.

The data shows that initial proposals were evaluated with major exceptions that factfinding was not able to resolve. As updates were presented, the data would track at or below the government's estimates, however the contractor would keep the estimate to complete at a level that was consistent with the original proposal rather than that of the actuals that were being incurred.

If we evaluate the chart tracking this data (fig 1) we see a consistent reduction in each of the contractor's updates, until completion of the effort which invariably would be less than the government's estimates. The final settlement was consistently below the government's original estimate.

FIG 1

C/O NTE	PROP	OBJ	S/A NEG
900,000	600,350	435,250	330,000
715,000	620,000	515,500	485,000
675,000	600,000	450,000	353,000
300,000	250,000	200,000	172,000

Why would this happen? I believe there are two reasons for the predictable nature of the data. First, the government utilizes the contractor's data as a basis for their technical position. The lack of history on these types of efforts complicates the analysis both by government and contractor personnel. As work is accomplished, it becomes less complicated and the primary evaluation becomes more a question of reasonableness. The technical reviewer can review incurred costs, utilize a modified cost performance technique and develop an overall cost to perform.

The proposal update data on the development contract did not reflect this adjustment. Some of this reluctance could be dictated by the normal conservatism of program

management in predicting the unknown. Many program managers are hesitant to dip into management reserve until most if not all tasks are completed.

Over time, the consistent nature of the proposals seems to indicate an alternate agenda. It is not unreasonable to opine that the contractor was attempting to artificially inflate the ceiling price on the modification in order to recover dollars on the basic contract that would otherwise need be recouped from corporate.

The pattern is unmistakable. The change order would be issued with an inflated not-to-exceed (NTE). The initial proposal would show a large decrease from the NTE. The technical review would indicate a problem with the estimating methodology, i.e. consistently high end. And the government's objective would be outside the band of negotiability. Additional factfinding would add time to the process during which the contractor would be required to provide updates containing actuals (due to the Truth in Negotiation Act). These proposal updates would trend downward, as would the government's objective. Until, finally, the actual data would result in a settlement which was not only lower than the contractor's proposals, but also significantly below the initial estimates of the government's technical team.

The eventual settlements of these change orders contained markedly reduced increases in the contracts ceiling price. Had the contractor merely accepted the government's initial offer, he would have realized a significantly greater increase in the contract ceiling price.

This approach is obviously not to be recommended for any but the most unique cases. It does not motivate the contractor to reduce cost incurrence, but rather would seem to incentivize him to spend unnecessarily. The data seems to indicate that, even with this potential, the government is better off using actuals in these cases than it would be to issue a unilateral or move toward the contractor's position.

I believe that some contractors realize the pressure that is levied on the government negotiation teams and try to game the process. They believe that once a change order gets old enough, management will pressure the government to compromise their position in the hope of reaching a settlement. Once contractors come to realize that the government team will not be pressured, they eventually revise their tactics and find additional negotiation flexibility in their position.

A final example of a situation in which the contractor attempted to use the "changes" provision to recover a negative financial position is a contract for software development in which the contractor accepted a low estimated cost in order to get a "beachhead" into a weapon system which had potential for additional business in the future. The contract required both software development and software maintenance. As problems surfaced, the contractor tried to have the government revise their estimated cost to reflect the resolution of those problems.

Under the cost plus contract, the contractor's costs were all recoverable, however, the contractor saw the changes as an opportunity to adjust the award fee and base fee. If the costs could be considered as changes, then the fee would be increased. Further, if the estimated cost of the change could be inflated, then the award fee pool would grow to reflect what their management

perceived as a more "reasonable" amount.

While some of the "changes" were clearly within the scope of the contract, some were additive in nature and change orders were approved for these efforts. The contractor proposals for these changes were inflated, based upon our technical review. When the actuals became available, it was clear that the increase to the estimated cost would be below even the government's objective. The fee increase would also be less than the basic contract since the risk was also reduced.

CONCLUSION

The basic premise that all change orders should be negotiated within a 180 day period needs to be revised. There are some instances in which the government is best served by allowing actuals to be negotiated. Management should be more flexible in allowing discretionary authority to the contracting office to slip schedule on the definitization of UCA's.

There are instances in which data indicates that waiting for actual data may be in the best interests of the government. As contractors come to accept that gamesmanship of UCA's is not in their interest it is possible that they may be motivated to become more responsive to negotiating UCA's even in those instances described above.

BEST VALUE CONTRACTS
LESSONS LEARNED IN PAVING THE ROAD TO QUALITY

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ABSTRACT

Vice President Gore's National Performance Review, published in September 1993, outlined twenty recommendations for reinventing Government procurement. One of those recommendations placed renewed emphasis on buying best value supplies and services. Executive Order 12931 implements this recommendation by requiring the government to "promote best value rather than simply low cost." This research paper explores the basis for confusion about the best value contracting process in light of its statutory basis, acquisition reform initiatives, and the implementation standards that continue to be defined by the boards of contract appeal and the courts.

INTRODUCTION

Best value is a quality focused approach to government contracting which is often misunderstood and inconsistently applied. Traditionally, the government has based the majority of its contract awards solely on price and price related factors. In many cases, however, the lowest priced product or service may prove to be false economy if, over the long term, there are excessive maintenance costs, late deliveries, or quality defects which result in greater overall costs. The large federal deficit and shrinking defense dollars of recent years have forced the government to direct its focus on ways to get the most value for its money. Thus, we have seen a growing shift to a quality based procurement philosophy. This philosophy encourages consideration of quality factors in addition to price alone and recognizes that the government can make tradeoffs between cost and quality factors and pay a premium for better quality, if it makes good business sense to do so. Even greater emphasis on best value can be expected in the future as a result of the Acquisition Streamlining Act of 1994[1] and Executive Order 12931[2] which encourage buying best value supplies and services and endorse the evaluation of past contract performance as a key quality consideration for awarding government contracts. Industry's concerns about the largely subjective nature of the best value process[3] and the lack of a commonly understood definition[4] have, however, led to an increasing number of protests in this area.[5] The objective of this paper is to analyze the government's best value process in order to provide a better understanding of some of its most difficult issues through a discussion of (a) pertinent statutes and regulations; (b) the impact of acquisition reform; (c) implementation concerns; and (d) lessons learned from selected protests.

STATUTE AND REGULATION

The Competition in Contracting Act (CICA) of 1984 established the foundation for the best value approach through its prescribed procedures for the planning, solicitation, evaluation, and award of

competitive government contracts.[6] In amending the civilian and defense agency procurement statutes,[7] the CICA's primary purpose was to place severe restrictions on the government's use of noncompetitive procedures and thereby enhance opportunities for all responsible sources to compete for government contracts. The CICA prescribes two basic methods for obtaining competition, sealed bidding and competitive proposals. The Act directs the government to select the approach that best fits the acquisition needs.[8] However, it also reflects a statutory preference for sealed bidding when all of the following criteria are present:

> (i) time permits the solicitation, submission, and evaluation of sealed bids;
>
> (ii) the award will be made on the basis of price and other price-related factors;
>
> (iii) it is not necessary to conduct discussions with the responding sources about their bids; and
>
> (iv) there is a reasonable expectation of receiving more than one sealed bid.[9]

Under the sealed bidding procedure, the government broadly publicizes the solicitation for competitive sealed bids, announces prices received at public bid openings, compares only prices and price-related factors of bidders who meet the clear requirements laid out in the specifications, and awards without discussion to the responsible bidder whose bid meets all the requirements of the solicitation at the lowest price.[10] The statutory preference for this method is based on the implicit fairness and simplicity of the sealed bidding process and the assumption that when the criteria for sealed bidding exist, the best value can be determined by a straightforward comparison of prices.

The statute permits the government to use the competitive proposals procedure (commonly known as competitive negotiations) only when it can show that sealed bidding is not appropriate in light of the four specified criteria. Under the competitive proposals procedure, the government may conduct discussions with the offerors and factor non cost related quality factors in with cost in making the award decision. The competitive proposals procedure would normally be used when the government has a need to seek out quality which cannot be determined by price alone and is willing to pay more for that quality. The General Accounting Office (GAO) has generally supported government discretion to use competitive negotiations unless its intent is to award solely on the basis of price and it cannot demonstrate a need for technical proposals.[11] Thus, in the recent case of *Premier Vending,* the GAO upheld the government's decision to use negotiations where a comparative evaluation of technical evaluation factors was warranted.[12] In *Raycal Filter Technologies,* however, the Army had used competitive negotiations but based the award solely on price and had no need for and did not request technical proposals. The competitive negotiations procedure was essentially used as an administrative convenience to facilitate the government's ability to deal with changes in requirements. GAO held that the possibility of changes was not in and of itself adequate basis to permit negotiations and sustained the protest upon finding that the four statutory factors for sealed bidding were present.[13] These cases illustrate that despite the current emphasis on best value, government agencies

still need to carefully analyze each individual requirement in light of the statutory criteria for sealed bidding before using a competitive negotiation approach.

To promote fairness in competition, the CICA also mandates that government solicitations use nonrestrictive specifications and clearly inform offerors of the groundrules (cost factors, non cost factors, and their relative importance) that the government will use in making the selection decision.

The Federal Acquisition Regulation (FAR) implements the statutory requirements of CICA, but gives little further procedural guidance. The FAR coverage on source selection in Subpart 15.602 describes the two approaches for conducting competitive negotiations as follows;

> (1) Cost or price competition between proposals that meet the government's minimum requirements stated in the solicitation; or
>
> (2) Competition involving an evaluation and comparison of cost or price and other factors.[14]

The first approach is commonly known as the Low Price Technically Acceptable (LPTA) approach. This involves a pass/fail evaluation of each offeror's technical proposal against the solicitation's minimum requirements, a comparison of the prices submitted by all offerors, and award to the technically acceptable responsible offeror submitting the lowest evaluated price. This is the simplest approach to competitive negotiations. It is generally used when the government needs more information to determine technical acceptability but also has confidence that the low offer will yield the best value for relatively straightforward requirements with no prior history of poor performance. The second approach is what is commonly referred to as the best value approach. Under this approach, the government not only evaluates the technical proposals but also ***compares*** the strengths, weaknesses and risks of the competing proposals in terms of ***both*** the ***cost and*** non cost or ***quality factors*** stated in the solicitation. The best value approach gives the government greater flexibility and discretion to make tradeoffs between cost/price and quality factors such as technical approach, management capabilities, and past performance in selecting the proposal offering the best combination of quality factors and cost. Under this approach, the government is not bound to award to the lowest price offeror. Although the FAR does not explicitly define best value, it comes closest to describing the concept at 15.605(c) where it states:

> While the lowest price or lowest total cost to the Government is properly the deciding factor in many source selections, in certain acquisitions, the Government may the select the source whose proposal offers the greatest value to Government in terms of performance and other factors.

PUBLIC VS PRIVATE SECTOR APPLICATION

Best value is a concept that is regularly used by the private sector when making major purchases. In the case of purchasing an automobile, a private consumer will rarely base the buying decision solely on price, but rather will weigh the cost against other more subjective quality factors such as handling, comfort, design, maintainability, and the customer service record of the dealer. In the private sector, the process is relatively

simple, unencumbered by rigid rules and not subject to protest from unsuccessful competitors. Commercial companies, in making buying decisions, are free to limit competition to a handful of good suppliers with whom they often establish long term relationships. As normal practice, they openly communicate with potential suppliers during all phases of the process and place a major emphasis on the record of past performance.[15] In contrast, the government process has become both complex and costly. This is because of the various statutes and regulations which mandate equal treatment and competition among all possible vendors. These rules, unique to government contracting, require consideration of social and economic issues and place severe limitations on any dialogue between the user and supplier during the solicitation phase.[16] This, and the risk of protest from unsuccessful competitors, contributes to the difficulties faced by the government purchaser in reasonably applying subjective judgment while protecting the rights of all sellers to compete on an equal basis for expenditure of public funds.

THE IMPACT OF ACQUISITION REFORM

While the best value concept is not new to the government,[17] recent efforts to streamline the government procurement system have resulted in a new emphasis on best value buying. This new high level emphasis, embodied in Executive Order 12931[18], implements the following recommendations of the National Performance Review (NPR) and acquisition reform legislation of the 103rd Congress.

THE NATIONAL PERFORMANCE REVIEW

Among the 20 recommendations for "Reinventing Federal Procurement" contained in the 1993 National Performance Review was a recommendation encouraging best value procurement.[19] This recommendation suggested that the government recognize quality factors in addition to price; define the term "best value"; and develop "best practices" guidance to facilitate the use of best value source selection procedures.

ACQUISITION REFORM LEGISLATION

The reforms contained in the Acquisition Streamlining Act of 1994 implement the recommendations in the National Performance Review. This Act amends the solicitation, evaluation, and award requirements of CICA by requiring that the Armed Services and civilian agencies clearly disclose to competitors not only the evaluation factors but also the subfactors that will impact the award decision. The Act also specifically recognizes past performance as a quality evaluation factor, mandates that cost or price be considered in the evaluation, and requires that solicitations disclose the relative importance of cost or price to all non cost factors combined.[20] With regard to past performance, the Act formalizes congressional recognition of an offeror's past contract performance as an important indicator of an offeror's potential to successfully perform future contracts. The Act further requires the government to develop clear guidelines that will assist agencies in their evaluation of contractor past performance.[21]

PAST PERFORMANCE INITIATIVE

The FAR never prohibited the government from evaluating past performance. In a 1990 study, however, Dr. Stephen Kelman, a Harvard professor of public policy, found that most government buyers of complex computer systems considered themselves forbidden to make comparative evaluations of competing offerors' past performance records when making decisions to award new contracts.[22] He further found that this belief evolved in the procurement culture from "doctrine that vendors may be evaluated only on their proposals" and not on extrinsic data.[23] Under such a system, he reasoned, there is little incentive for suppliers to do a good job once they win a contract.[24] His concluding recommendations included making past performance a formal evaluation factor[25] and dramatically increasing public officials' discretion to use their own judgment in evaluating past performance in selecting contract sources.[26]

Since Kelman's confirmation in November of 1993 as the seventh administrator of the Office of Federal Procurement Policy (OFPP), he has worked to make the consideration of past performance in award decisions a top priority.[27] Almost a year before Kelman's appointment, in January 1993, the OFPP issued past performance policy in Policy Letter 92-5.[28] The new policy required government agencies to collect past performance information on its contracts and to use that information in evaluating competitively negotiated offers over $100,000. One of Kelman's first major efforts as OFPP administrator was to launch a pilot program to foster use of past performance in source selections and to facilitate implementation of the policy.[29] Under the pilot program, initiated in January 1994, the OFPP and twenty federal agencies signed voluntary pledges to make past performance a significant factor in selecting contractors on sixty-one designated contracts scheduled for award over an eighteen month period. The experiences gained during the pilot will be key to development of the past performance guidance directed by the 1994 acquisition reform legislation.[30]

IMPLEMENTATION CONCERNS

Increasing use of the best value approach has raised concerns in both the private and public sectors about its effective implementation.

INDUSTRY. In November 1993, the Information Technology Association of America (ITAA) issued a position paper on the use of the best value approach in government acquisitions of information technology. A summary appearing in *Federal Contracts Report*[31] indicated that ITAA, while supporting use of the best value concept for complex acquisitions, emphasized the need for a number of changes in the way in which the government conducts its best value acquisitions. Some of the recommended changes included adequately defining government needs in functional terms to encourage innovative offeror solutions; communicating as much information as possible to offerors about mission objectives and evaluation factors early in the process; and ensuring that government officials are adequately trained in making cost/technical tradeoff analyses and judgmental business decisions. In the services contracting arena, concerns have also been voiced by the Professional Services Council. In its proposal for reform, the Council advocates use of a best value approach but also notes that the government

often tends to place too much emphasis on cost at the expense of quality.[32] In the accompanying working paper on best value procurement, the Council states that although some agencies attempt to use a best value approach, often "these efforts lack the rigor and procedural discipline needed to avoid excessive price/cost bias in source selection."[33]

DEPARTMENT OF DEFENSE (DOD).

Industry concerns are echoed in a June 1994 DOD Inspector General (IG) report on a sampling of 19 formal source selections conducted by various DOD activities between 1989 and 1991.[34] The findings identified a number of systemic problems associated with DOD's implementation of the best value concept. One of the key problem areas was confusion over the definition of "best value". In the course of interviewing 56 program managers, evaluators, and contracting officers, the IG found no certainty or consistency in "what constituted a 'Best Value' determination".[35] Other concerns highlighted problems with poorly defined evaluation criteria, too many evaluation criteria and vague and inconsistent solicitation language.[36] Although most of the programs in the survey used about 20 evaluation criteria, one of the major programs surveyed used 645, another used 90, and a third used 73.[37] Excessive numbers of evaluation criteria make evaluation overly complex and dilute the government's ability to effectively discriminate among the offerors. The report also cited inadequate understanding of the difference between the Low Price Technically Acceptable (LPTA) and best value approaches. This was reflected in many of the solicitations in the survey that stated award would be made on the basis of best value but where other language in the same solicitation actually described a LPTA approach.[38] Recommendations for improvement addressed establishing consistency in the execution of best value contracts, streamlining the process, and ensuring adequate training of those who participate in the process.[39]

LESSONS LEARNED IN SELECTING FOR QUALITY

The critical questions that government activities must address in making best value decisions are what constitutes "quality" and how do you measure the value of that quality. In making the best value award decision, the government has broad discretion as long as the decision is rational, consistent with the evaluation criteria, and well documented.[40] The evaluation criteria and their relative importance play a major role in any cost/technical tradeoff analysis. Ultimately, however, the selection decision must revolve on the significance of the differences between proposals and to what extent the government is able to demonstrate whether the superior quality of a particular proposal warrants the difference in cost.[41]

MEASURING THE VALUE OF QUALITY

Some recent cases illustrate a growing trend for contract appeal boards to demand a more exacting measurement of value to justify payment of a price premium. This may mean quantifying the value of the benefits as reflected in the following cases.

Justifying the Ultimate Price Premium. The Federal Circuit Court of Appeals decision to uphold the $1.4 billion dollar award to AT&T for the Treasury, Multi-User Acquisition Contract (TMAC) is perhaps the most dramatic best value

decision to date. The TMAC requirement covered office automation systems and associated software, maintenance and support services for the Internal Revenue Service (IRS). The evaluation factors were broadly crafted stating in part:

> Award will be made to that offeror whose proposal, containing the combination of technical, management and support, and cost features, offers the best overall value to the government. The Government is more concerned with obtaining superior technical (technical and management and support) features than making award to the lowest cost. Award will be determined by comparing differences in the value of technical features with difference in overall cost to the Government...[42]

IRS awarded the seven year contract to AT&T at an evaluated price of $1.4 billion. Lockheed and IBM, whose evaluated prices were $900 million and $700 million, respectively, protested the award to the General Services Board of Contract Appeals (GSBCA), arguing that the award was not proper in light of the much higher cost of the selected proposal. The Board sustained the protests, finding that there was "nothing in the record to explain how AT&T's technical advantage justified the price premium of one-half to three-quarters of a billion dollars that the IRS was willing to pay."[43] The board returned the action to the IRS for a more detailed evaluation after concluding that the IRS' cost/technical tradeoff analysis was not meaningful. The IRS then performed an extensive analysis in which they quantified in terms of dollars some of the proposal differences considered most likely to impact IRS operations. As a result, the IRS again concluded that the value offered by the AT&T proposal warranted the price premium. Lockheed and IBM protested once more to the GSBCA.[44] In reviewing the IRS's more detailed analysis, the GSBCA looked at the methodology used to perform the cost/technical tradeoff. This approach included the use of discriminators, drawn from the strengths, weaknesses, and risks of the proposal evaluation, which were determined to (1) reflect significant areas of differences between the proposals; (2) be important to the objectives of the program; and (3) have an impact on IRS operations.[45] The IRS divided the discriminators into 4 quantified areas and 10 non-quantified impact areas. The differences in the four quantified areas were determined to have a direct relationship to user productivity or price risk and were translated into dollars. These areas addressed the impact of technology on contract price risk; the impact of performance on mission productivity; the impact of software integration on end-user productivity; and the impact of training on end-user productivity. Although the protesters challenged the IRS's assumptions and their choice of discriminators, the board supported both the method used in performing the cost/technical tradeoff and the IRS' decision because they were found to be reasonable and consistent with the solicitation criteria. The board emphasized that an agency has a great deal of discretion in conducting the tradeoff analysis as long as it is reasonable and demonstrates that the expected benefits are worth the premium in price. Lockheed argued that, based on the fact that only four areas were selected for a quantitative analysis, it would have had to offer its products at no charge in order to get the award. In response, the Board stated,

> "...we perceive no reason why goods and services cannot have a value to their purchaser that exceeds their

price. One has only to think of an automobile air bag."[46]

The board also noted that none of the competitors had protested the broadly stated evaluation provisions prior to receipt of initial proposals. Absent any objection to the groundrules laid out in the solicitation, the IRS had considerable discretion in selecting the method used to compare proposals and was found not to have abused that discretion in conducting its subsequent cost/technical tradeoff analysis.[47]

Lockheed's appeal to the U.S. Court of Appeals for the Federal Circuit was also denied.[48] In its decision, the Court cited numerous cases which support the government's broad discretion in making the best value decision. It further found that the productivity dollar value of the AT&T solution far outweighed that of the other proposals although, in terms of point scores, this represented less than 15% of all available points. Thus, it noted that

> ...a proposal which is one point better than another but costs millions of dollars more may be selected if the agency can demonstrate within a reasonable certainty that <u>the added value of the proposal is worth the higher price.</u>[49] (emphasis in original)

In this case, the Court supported the IRS in its selection because it was able to clearly demonstrate, by quantifying some of the key discriminators, that the added benefits were worth the added cost.

Payment of Price Premium More Closely Scrutinized Where Technical Differences Are Slight

In a case where the evaluation reflected no significant weaknesses in the closely rated technical proposals, the Board sustained the protest because the record did not adequately show that the value of the benefits to be derived from the slightly higher rated offerors justified the higher prices.[50] The protest was filed by B3H Corporation in response to best value contract awards made by the Air Force to two small businesses. The solicitation involved a requirement to provide technical support services for communication/computer systems (C-CS) as part of an effort to modernize the Air Force's logistics program. The evaluation criteria outlined in the solicitation were technical, management, and cost. Technical and management were specified as being of greater importance than cost. The solicitation also stated that the government would evaluate proposal risk, performance risk, and cost realism. The Air Force used a color rating system which graded proposals as blue, green, yellow, or red, with blue being best. The two awardees and the protester all scored in the blue and green zones, had low performance and proposal risks, and no significant weaknesses.[51]

In evaluating costs, the government compared the offerors' proposed costs for performing the sample statement of work to the government's estimate for performing the same task. The GSBCA found this methodology to be defective because it did not take into account the offerors' varying approaches and thus leveled the differences between proposals.[52]

The Air Force also performed an impact analysis to determine which comparative differences between proposals would significantly impact the overall value to the government. Using a methodology similar to that used in the TMAC case, the agency identified seven discriminators for further analysis. However, only one of the

discriminators was subject to quantification. The selecting official used the results of the impact analysis to look behind the relatively small technical and management differences. The source selection authority (SSA) concluded that the awardee's management strengths, as reflected in the greater efficiency and overall quality of software development, provided a value that warranted payment of a price premium of approximately 15%.[53] In spite of the detail of the impact analysis, the board criticized the fact that the Air Force had only quantified one of the seven discriminators finding that,

> The record does not associate any specific monetary value with the advantages of the three proposals to the agency in any greater detail and in a more convincing fashion than the broad generalities and simple conclusions of the SSA.[54]

The board also played down the SSA's concern about possible cost overruns associated with the protester's proposal, indicating that a task order contract allows the government a mechanism for controlling and distributing risks to perform certain tasks.

The board, in finding a lack of clear evidence that the differences in the substantially similar proposals were worth the added cost, stated,

> Although mathematical precision or absolute dollar quantifications are neither expected nor required, more than a mere conclusion is required to justify a best value analysis."[55]

The board further found that in this case a particularly strong justification was needed since the use of a task order contract gave the agency more discretion to control contractor performance through the placement of individual task orders. Under such circumstances, and especially where technical differences are small or where cost differences are large, the greater the need for a more in-depth tradeoff analysis to justify the best value decision.

It is interesting to note that a strong dissenting opinion was filed by Judge Donald W. Devine based on his assessment that the Board had interjected its judgment for the SSA in an area which should be within the discretion of the decision making official. In his opinion, he noted that the board had ignored extensive testimony of the SSA which showed that the price premium was justified in light of the agency's prior experience with these requirements and the awardees' better qualifications which would improve productivity and task performance. Further, he stated that contract appeals boards are not qualified to judge whether a particular company's qualifications may or may not be worth the additional cost in providing specific contract services with which only the agency is intimately familiar. Noting that the difference between the two awardees' costs and the protester's costs were only 15% and 5% respectively, he wrote,

> Under such circumstances, the Board should never intrude. In this decision, the Board has become the Omniscient Source Selection Authority that it was never meant to be.[56]

In spite of Judge Devine's dissenting opinion, the Air Force's decision was overturned by the board because it lacked sufficiently clear measurement of the value of the small technical differences necessary to justify the added cost.

EVALUATION CRITERIA AS GUIDELINES FOR THE SELECTION DECISION

The selection decision must be made within the framework of the stated evaluation criteria. However, the selection official has considerable discretion in making judgments about the significance of differences in competing proposals and in weighing quality factors against cost. The following cases illustrate that the relative importance of the evaluation criteria in the solicitation are merely broad guidelines, not rigid and limiting rules for the selection decision. Thus, even where the evaluation criteria in the solicitation state that the technical factor is more important than cost, the boards have supported award to a lower priced offeror if the slight technical differences do not support payment of the price premium. In *TRW, Inc.*, the GSBCA supported the Air Force's decision to award to a lower priced offeror where the slight technical superiority of the protester's offer did not warrant an \$11.7 million price premium.[57] In this case, TRW had argued that the Air Force's decision to award a large information technology technical support contract to CSC was flawed because the Air Force had not quantified the technical advantages of TRW's proposal in making the cost/technical tradeoff. The GSBCA rejected TRW's argument finding that, where technical differences between competing proposals are slight, the government is not required to quantify the differences if they do not warrant payment of a large price premium. Similarly, in *Sherikon, Inc.*, the GAO supported the Navy's decision to award to a lower-priced offeror where the 6 point difference in technical ratings was found to be not significant enough to warrant a 12% premium in price.[58]

In *Brunswick Defense*, where price was the most important evaluation factor, the board upheld the discretion of the selection authority to award to a higher priced offeror where the record showed clear evidence that the low priced offeror presented an unacceptable performance risk.[59] In this case, which involved a Naval Air Systems Command requirement for target missiles, the solicitation stated that price was significantly more important than the technical factor which was moderately more important than the past performance/systemic improvement factor. The solicitation also put offerors on notice that the government was not bound to award to the lowest price offeror if the technical advantages of a higher priced offeror justified payment of the price premium.[60] Brunswick's proposed price of \$73 million was approximately 18% lower than Beech's price of \$91 million. With regard to the technical factor, both proposals were rated as satisfactory overall with Beech's proposal reflecting low risk and Brunswick's medium risk. In the area of past performance/systemic improvement, Beech received a satisfactory/low performance risk rating while Brunswick was rated as unacceptable with high performance risk due to a series of previously unsuccessful missile launches.[61] After extensive discussions in which Brunswick was given the opportunity to explain past performance failures and plans for corrective action, the Navy concluded that Brunswick still presented a high performance risk. The Navy then quantified missile replacement costs and range operation costs resulting from Brunswick's past record of 50% reliability rate compared with Beech's 96% reliability rate. As a result, the Navy found that award to Brunswick would result in significant

additional costs ($33 million).[62] Although the selection official made the decision to award to Beech on September 28, the award was delayed until November 5 as a result of internal management briefings. On November 1, Brunswick made its first successful missile launches. The selection official learned of the launches on November 3, but did not reopen discussion as the award decision had already been made. The protester argued that the Navy should have reopened the evaluation after learning of Brunswick's four successful flights just days before the award. GAO disagreed, finding that the government did not have to delay award to enable the protester to bring its performance record up to an acceptable level since the selection official had already made the selection decision a month earlier.[63] Citing Grey Advertising, Inc., 55 Comp Gen 1111 (1976), 76-1 CPD ¶325, GAO found that

> source selection officials in negotiated procurements have broad discretion in determining the manner and extent to which they will make use of the technical and cost evaluation results. Agencies may make cost/technical tradeoffs in deciding between competing proposals; the propriety of such a tradeoff turns not on the difference in technical scores or ratings, *per se*, but on whether the selection official's judgment concerning the significance of that difference was reasonable and adequately justified in light of the evaluation scheme.[64]

SUMMARY

Protest statistics confirm many of the problems associated with implementing the best value approach. Protests related to improper evaluation and negotiation are sustained for several major recurring reasons. These include failure to follow the stated evaluation criteria; failure to conduct meaningful discussions; failure to analyze cost realism properly; and failure to conduct proper cost/technical tradeoff analyses.[65] Such problems emphasize the importance of a well planned acquisition process which begins with converting customer needs and performance objectives to performance based requirements; clearly communicating those needs and criteria for quality to industry in the solicitation; properly evaluating proposal risk, cost realism, and performance risk consistent with the evaluation criteria; conducting meaningful discussions; and making a rational, well documented award decision. The boards and courts, as protest forums, will undoubtedly continue to define the level of discretion of the selection official and the degree of justification for cost/technical tradeoffs in the best value process.

CONCLUSION

The best value product or service in federal acquisition can be achieved by traveling one of several roads. Both the sealed bidding and competitive negotiation routes will lead to quality under the appropriate circumstances. Misunderstandings arise because best value has become a term of art for the competitive negotiation procedure where we consider factors in addition to price. Compounding the confusion is the fact that there have been few road maps describing the most appropriate routes for the journey and potential detours along the way. Clearly, the sealed bid route is the most straightforward and appropriate when quality can be determined from a comparison of conforming bids on the basis of price alone. The low price technically acceptable proposal route requires more stops along the way and is appropriate when quality can be

determined on the basis of low price but only after a thorough evaluation and discussion of technical proposals to ensure they meet more complex government requirements. The route that is known as the best value approach is appropriate when quality cannot be determined by low price alone. This route is perhaps the least understood because it requires considerable subjective judgment to negotiate the curves and detours along the way. Under the best value approach, there is no easy formula for measuring the value of benefits the government receives. While justification is always necessary to support payment of a price premium, the need to quantify the value of non cost benefits will differ in each case and depend largely upon whether it makes sense to do so to help support the decision.

While the best value approach is not new, the recent reforms in federal procurement require executive agencies to, "promote best value rather than simply low cost in selecting sources for supplies or services."[66] To accomplish this, there must be substantial efforts to educate both the government acquisition work force and industry in best practices so as to establish a common understanding of the concept and consistency in its application to making best value business decisions.

The ultimate challenge in promoting best value will be to develop the necessary road maps and tools to incentivize the acquisition work force to effectively manage rather than avoid risk and use common sense and innovation in selecting contract sources which provide the best value for the American taxpayer.

ENDNOTES

[1] Congressional Record-House. (August 21, 1994). Conference Report to accompany S.1587, 103rd Congress, 2nd Session, The Federal Acquisition Streamlining Act of 1994, Sec 1091, H8887. (The Act was signed into law on October 13, 1994).

[2] Executive Order 12931. (October 13, 1994). Federal Procurement Reform, 59 FR 52387, 1994 WL 566458 (Pres.): Sec. 1(d).

[3] Bail, P. (March, 1993). "Best value is subjective but here to stay", *Federal Acquisition Report:* 14.

[4] Koch,D. (May, 1994). "Best value procurements: disclose the price/technical tradeoff!", *Contract Management*: 11.

[5] Lieberman, R. (January 31, 1994) "Winning bid protests in three forums: a statistical analysis at the U.S. postal service, the GAO, and the GSBCA," Federal Contracts Report, Vol 61, No. 4: 10. Lieberman's statistics show that from FY91-FY93, over one third of the protests granted by the GAO and nearly half of the protests granted by the GSBCA were caused by government failure to evaluate, negotiate, or select offerors properly in best value acquisitions.

[6] The Competition in Contracting Act of 1984, Public L. No. 98-369, Division B, Title VII, 98 Stat. 494, 1175, Sec 303A.

[7] The Competition in Contracting Act (CICA) amends the Federal Property Administrative Services Act of 1949, (41 U.S.C. 253), applicable to civilian agencies and the Armed Services Procurement Act of 1947, (10 U.S.C. 2304 and 2305), applicable to the Department of Defense.

[8] 41 U.S.C. 253(a)(1)(B) and 10 U.S.C. 2304(a)(1)(B)

[9] 41 U.S.C. 253(a)(2) and 10 U.S.C. 2305(a)(2).

[10] Federal Acquisition Regulation,(FAR) Subpart 14.1.

[11] Nash, R.C. & Cibinic, J.(1993). *Competitive Negotiation: The Source Selection Process. Washington, D.C.:* The George Washington University, National Law Center, Government Contracts Program, 91.

[12] *Premier Vending*, (June 23, 1994), GAO B-256437, 94-1, CPD¶380.

[13] *Raycal Filter Technologies*, (Dec 4, 1990) 70 Comp. Gen. 127, B-240579, 90-2 CPD¶453.

[14] FAR 15.602(a).

[15] Defense Analysis and Studies Office Study. (December 15, 1989). *Best Value Evaluation Process.* Falls Church, VA: Defense Analysis and Studies Office.

[16] Cooley, W.(May, 1994). "Acquisition of microcomputers as commodities", Contract Management:6.

[17] See Nash 1, which indicates that the competitive negotiation process first appeared in the Armed Services Procurement Act in 1962 and became a part of CICA in 1984.

[18] Executive Order 12931, Section 1(d): 1.

[19] Report of the National Performance Review, (September, 1993), *From red tape to results, creating a government that works better and costs less.* Washington, D.C.: U.S. GPO. 164-165.

[20] Congressional Record,
H8882 Armed Services, (amends 10 U.S.C. 2305(a)) and H8885 civilian agencies, (amends 41 U.S.C. 253(a) and 253(b).

[21] Congressional Record 8887.

[22] Kelman, S. (1990). *Procurement and public management: The fear of discretion and the quality of government performance.* Washington, D.C.: The AEI Press. 41.

[23] Kelman 43.

[24] Kelman 64.

[25] Kelman 91.

[26] Kelman 90-92.

[11] Nash, R.C. & Cibinic, J.(1993). *Competitive Negotiation: The Source Selection Process. Washington, D.C.:* The George Washington University, National Law Center, Government Contracts Program, 91.

[12] *Premier Vending*, (June 23, 1994), GAO B-256437, 94-1, CPD¶380.

[13] *Raycal Filter Technologies*, (Dec 4, 1990) 70 Comp. Gen. 127, B-240579, 90-2 CPD¶453.

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[15] Defense Analysis and Studies Office Study. (December 15, 1989). *Best Value Evaluation Process.* Falls Church, VA: Defense Analysis and Studies Office.

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H8882 Armed Services, (amends 10 U.S.C. 2305(a)) and H8885 civilian agencies, (amends 41 U.S.C. 253(a) and 253(b).

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[22] Kelman, S. (1990). *Procurement and public management: The fear of discretion and the quality of government performance.* Washington, D.C.: The AEI Press. 41.

[23] Kelman 43.

[24] Kelman 64.

[25] Kelman 91.

[26] Kelman 90-92.

[27] "Kelman outlines priorities, pledges not to duck tough decisions," (December 6, 1993) *Federal Contracts Report*, Vol. 60: 565.

[28] OFPP Policy Letter 92-5 (January 11, 1993). *"Past performance information,"* 58 Fed. Reg. 3573.

[29] Federal Contracts Report, Vol. 61: 129, 160

[30] Congressional Record 8887.

[31] "Best value procurement, ITAA urges changes in best value process," (December 6, 1993). *Federal Contracts Report*, Vol 60: 574.

[32] Professional Services Council. (1994). *"Professional and technical services contracting."* Reform Proposal. Unpublished paper.

[33] Professional Services Council. (1994). *"Best value procurement for professional and technical services,"* Working Paper.

[34] Inspector General Department of Defense Inspection Report, 94-INS-09. (June 22, 1994). *Source Selection Process.*

[35] Ibid at 17.

[36] Ibid at 10.

[37] Ibid at 58.

[38] Ibid at 13, 18.

[39] Ibid at 23, 24, and 40.

[40] Rules laid out in *Grey Advertising, Inc.*, (1976), 55 Comp Gen. 1111, 76-1 CPD ¶325.

[41] Nash 501.

[42] *Int'l Business Machines Corp.*, GSBCA No. 11359-P, et al, (1991), recon. denied, 1991 BPD ¶273 at 7-8.

[43] *Ibid* at 27-28.

[44] *Lockheed Missiles & Space Co.*, GSBCA No.11776-P, (1992) BPD ¶155.

[45] Ibid at 1.

[46] Ibid at 22.

[47] Ibid at 23.

[27] "Kelman outlines priorities, pledges not to duck tough decisions," (December 6, 1993) *Federal Contracts Report*, Vol. 60: 565.

[28] OFPP Policy Letter 92-5 (January 11, 1993). *"Past performance information,"* 58 Fed. Reg. 3573.

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[33] Professional Services Council. (1994). *"Best value procurement for professional and technical services,"* Working Paper.

[34] Inspector General Department of Defense Inspection Report, 94-INS-09. (June 22, 1994). *Source Selection Process.*

[35] Ibid at 17.

[36] Ibid at 10.

[37] Ibid at 58.

[38] Ibid at 13, 18.

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[40] Rules laid out in *Grey Advertising, Inc.*, (1976), 55 Comp Gen. 1111, 76-1 CPD ¶325.

[41] Nash 501.

[42] *Int'l Business Machines Corp.*, GSBCA No. 11359-P, et al, (1991), recon. denied, 1991 BPD ¶273 at 7-8.

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[44] *Lockheed Missiles & Space Co.*, GSBCA No.11776-P, (1992) BPD ¶155.

[45] Ibid at 1.

[46] Ibid at 22.

[47] Ibid at 23.

[48] *Lockheed Missiles & Space Co. v. Bentsen*, 4F.3d No 92-1566 (Fed Cir. Aug 30, 1993).

[49] Ibid at 11.

[50] *B3H Corporation*, GSBCA No. 12813, (Jul 8, 1994).

[51] Ibid at 7.

[52] Ibid at 11.

[53] Ibid at 11.

[54] Ibid at 15.

[55] Ibid at 15.

[56] Ibid at 18.

[57] *TRW, Inc.*, GSBCA No. 11309-P, 92-1 BCA ¶24,389.

[58] *Sherikon, Inc., Technology Management & Analysis Corporation,* GAO, B-256306; B-256306-2; B-256306-3, (June 7, 1994), CPD 94-1, ¶358.

[59] *Brunswick Defense,* GAO, B-255764,(March 30, 1994), CPD 94-1 ¶225.

[60] Ibid at 2.

[61] Ibid at 3.

[62] Ibid at 6.

[63] Ibid at 8-9.

[64] Ibid at 8.

[65] Lieberman 8 (see Note 6).

[66] Executive Order 12931, Section 1(d).

COST AND RESOURCE MANAGEMENT

A MICROECONOMIC ANALYSIS OF SOVIET MILITARY SYSTEMS ACQUISITION

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ABSTRACT

This paper examines key microeconomic aspects of the former Soviet Union (FSU) military systems acquisition process. Differences in the FSU and U. S. military acquisition processes are provided using a common microeconomic framework. Recommended changes to U. S. military systems acquisition policy are provided based upon observations of FSU policy and hypothesized outcomes from the microeconomic framework.

The recommended changes to U. S. policy involve: (1) selecting initial program performance requirements in a less biased fashion versus the anticipated level of program cost and schedule, (2) set the resulting cost, performance, and schedule (C,P,S) solution point in a somewhat more conservative manner, and (3) reducing the degree of reluctance to decrease performance during the course of the development program if the C,P,S solution point appears to be infeasible.

INTRODUCTION

This paper examines key microeconomic aspects of the former Soviet Union (FSU) military systems acquisition process. A brief discussion is given of the FSU military systems acquisition structure, followed by the relevant microeconomic characteristics associated with the FSU counterparts of the U. S. military system buyer (government) and seller (contractor). Differences in the military acquisition processes of the two countries are provided using a common microeconomic framework. This framework was originally developed to model the U. S. military acquisition process. Hypothesized outcomes from the microeconomic framework for the U. S. case are highly consistent with results obtained from a broad sample of U. S. defense programs spanning the 1950s through 1980s [1]. The same preferences, interactions and outcomes also apply to highly classified ("Black") programs and NASA space programs [1]. The microeconomic framework was extended to model the FSU acquisition process, and a summarized version of the framework is presented in this paper. Finally, recommended changes to U. S. military systems acquisition policy are provided based upon observations of FSU policy and hypothesized outcomes from the microeconomic framework.

Substantial differences exist between the acquisition processes of the two countries', in terms of preferences between buyers and

sellers, program dynamics, and likely solution points. In some but not all respects, the FSU acquisition process was superior from a microeconomic perspective to that commonly employed in the U. S., where moderate cost and schedule growth occurs in most major military acquisition projects [1].

Considerable change has existed in the FSU and its military acquisition process during the past five to 10 years. As a result, a high degree of uncertainty surrounds western analysis of the FSU acquisition process. It is not my intent to address the highly fluid nature of the relatively recent FSU acquisition process, but to examine in some detail the process in place until about 1987. Since some evidence suggests that the Soviet military acquisition process was already changing in the late Brezhnev period, the description and model presented below are most applicable to the "classical" Soviet military acquisition process from roughly 1950-1980 [2]. Although this may appear dated, the majority of the Cold War arms buildup occurred in both the U. S. and FSU prior to 1987, and during 1950-1980. Thus, a comparative analysis through 1987, with emphasis from 1950-1980, will present some important lessons learned both from purely a historical perspective, as well as to provide valuable insight for future U. S. military development programs.

(For simplicity sake, I will generally use the term Soviet rather than FSU throughout this paper except in a few specific cases. In addition, I use the U. S. military acquisition program phase names that existed between March 19, 1980 and February 22, 1991, which are in order of increasing maturity: (1) Concept Exploration, (2) Demonstration and Validation, (3) Full Scale Development, and (4) Production. These acquisition phases correspond to those currently in use, which are in order of increasing maturity: (1) Concept Exploration and Definition, (2) Demonstration and Validation, (3) Engineering and Manufacturing Development, and (4) Production/Deployment.)

FORMER SOVIET UNION MILITARY SYSTEMS ACQUISITION APPROACH

An early typical milestone in the Soviet military acquisition process was when the Soviet service armaments directorate converted a military systems proposal to a draft Tactical Technical Instruction (TTI), which specified a new system's rationale, estimated cost, and operational role. (The information in this section was extracted from the unclassified work of Berenson and Carley [3], the Government Accounting Office [4], and Alexander [5] through [11].) It was similar to the Required Operational Capability document in the U. S. When approved by the government and military elements, a scientific-technical commission reviewed it for feasibility and producibility, possibilities for standardization, etc. (In effect, the estimated cost was established by the system requirements negotiated within the military and the subsequent design. On the surface it was very similar to the U. S. case, but the Soviet development phase starting point was likely more conservatively set because of risk aversion considerations than in the U. S. case.) The proposed Soviet military system was then examined by a research institute, which performed exploratory analyses. The resulting documentation was then turned over to several design bureaus to lay out, among other things, their own system concept. The scientific-technical commission then selected the most promising design or designs, acting as a source selection board.

The next step was to convert the designers' concepts into semi-detailed drawings and then into working prototypes. These prototypes sometimes embodied different technological approaches and competed against one another, especially in aircraft programs. Prototype design and construction methods were regulated by design handbooks in order to minimize program risk. Military system production did not occur until the prototype was proven. Military system designers were required by law to evaluate alternative system concepts against such criteria as reliability, producibility, and standardization.

Prototypes underwent extensive laboratory and factory trials conducted by the design team, factory management and the military customer to check adherence to the TTI. The prototype was sometimes refined before "state trials" began. (These "state trials" were conducted by the defense ministry concerned, the Military Industrial Commission (VPK), and the military commander.)

Once the prototype was approved, funds were provided for the equivalent of the U. S. Full Scale Development (FSD) program phase. The major development decision made in the U. S. to approve the resources required to proceed with FSD is the Milestone II. In the Soviet Union, it was the Joint Decree of the Central Committee of the Communist Party and the Council of Ministers (responsible for implementing the policies originating in the Communist Party). The Joint Decree was the first and possibly only, major approval of the Soviet Union whereas it is the second of the three major approvals in the U. S. systems acquisition procedure (the first and third being Milestone I and Milestone III, corresponding to decisions to enter the Demonstration and Validation and Production phases, respectively).

Technology freeze occurred in the Soviet programs about the time the Experimental Design Work (OKR) Development Phase (equivalent to FSD) began; while it is usually years later in the middle of FSD in U. S. programs, as a result of the Soviet schedule and U. S. performance priorities.

The Soviet design team was not finished with the military system when it was turned over to the production plant. A design team engineer accompanied the transfer and was on hand until production was completed. The designer had a large say in the military system production process, and was held chiefly responsible for quality and schedule.

In the U. S., accountability for system design is diffused. Historically, there has been a strong incentive for both the government and contractors to make overly optimistic development phase proposals. On the other hand, “the contractual penalties for having been overoptimistic are generally small.” [12]

However, in the Soviet case the designer was prominently identified and held responsible for success or failure, which contributed to a conservative design policy. The net result was to drive many Soviet military system designs to incremental levels of technology advance, while firmly attempting to meet program schedule (and to a somewhat lesser extent cost). The lack of severe penalties in the U. S. case removes one disincentive for the program manager and contractor counterpart in attempting to seek a higher level of technology. In addition, it may also indirectly contribute to a higher level of U. S. military program operating slack (which may translate into increased cost and/or schedule).

U. S. resource commitments for military programs are revisited on a yearly basis because of Congressional approval requirements, while Soviet resources were typically committed for the full program once directed by the issuance of a Joint Decree.

The Soviet military did not have a production phase budget with line items for individual systems. Instead, once the program was approved through a Joint Decree, the Ministry of Finance set up an account for the designated suppliers. In effect, there were no financial links between the military (user), the Ministry of Finance (funding source), and the suppliers (seller). Since production phase funding was contained outside the Soviet military budget, the budget was limited to personnel and Operations and Support (O&S) expenditures. The Soviet military budget was different than the U. S. military budget, which also included funding for the system development and production program phases. (Historically, financial budgets were not a principal source of control over Soviet military expenditures but rather were an after-the-fact accounting device that followed the planning of physical programs and material balances.)

No military system production in Soviet plants began until development and testing was complete. Concurrency in Soviet programs was thus rare, except for crash programs. Cost overruns were not tolerated historically by the hierarchy, and cost estimates included padding to guard against them. (The Soviet policy pertaining to cost overruns was apparently softened during the past decade.) In the U. S., concurrency occurs in some military programs; cost and schedule estimates tend to be optimistic; and cost overruns and schedule slippage are common. U. S. military system development phase cost and schedule growth are linked to the desire to meet performance requirements, coupled in some cases with pushing technology and trying to manufacture unproven designs.

In the Soviet military system procurement case, the buyer equaled the seller to a much greater extent than in the U. S. case. Hence, there was a greater tendency to "conform" in the Soviet case to the buyer's wishes (particularly if pressure was applied from the central government). The pressure to conform likely existed whether or not development and/or production competition was used.

SOVIET AND U. S. MILITARY SYSTEMS ACQUISITION PRIORITIES

Historically, the top priority of Soviet programs was to meet a preset schedule; while the top priority of U. S. programs is performance. In addition, the U. S. tends to use new technology for each new military system to provide maximum performance and to serve as a force multiplier, albeit that increasing performance for a given level of technology will tend to increase cost and/or schedule. The Soviets historically emphasized the extensive use of technology transfer to keep pace with the technology in threat impacted systems, and used off-the-shelf components, with modest performance upgrades in some cases, for producibility considerations to help meet the schedule in other programs. Designs were typically well within the world-level state of the art, and performance goals were modest for all but stressing systems (e.g., threat impacted). In addition, the Soviets rarely included more than one new technology at a time in a military system design. However, the Soviets could and did develop technologically advanced systems when

needed (e.g., Typhoon submarine). The Soviets also emphasized relatively low cost military systems, albeit at somewhat lower levels of performance than comparable U. S. systems, and compensated for the performance difference by the procurement of large quantities.

There was greater use of product improvements in the Soviet Union, which proceeded in parallel with new developments. The use of product improvement reduced the need for the Soviets to push technology in each development program since if the next program didn't achieve the desired performance level, the one starting a few years later would come closer. In addition, the phasing of product improvements and new system developments allowed full employment to be maintained and effectively used at the major design bureaus.

Given these constraints, and the Soviet preference for low cost designs, simplicity, standardization, and incremental improvement were often evident in Soviet military programs. A summary of some of the differences in U. S. and Soviet Design Practices is given in Table 1 [13].

The Soviet design philosophy tended to minimize uncertainty in the system development phase, and reduced the number of problems in the production phase. The Soviet acquisition process was a sequence of disciplined, risk-avoiding steps (except for specially designated higher risk military systems). Tight schedule deadlines were typically imposed, and approval of each step completed was marked by the joint signatures of system designers, government monitors, and military customers. Design

SOME UNITED STATES AND FORMER SOVIET UNION
MILITARY DESIGN PRACTICES

TABLE 1

Element of Design	**United States Design Practice**	**Soviet Design Practice**
Design philosophy	Design to maximize performance	Design to functional requirements
Growth philosophy	Advanced technologies, Emphasis on growth potential	Low risk design, Little growth potential
Reliability	Designed-in	Off-the-shelf components; proven technology
Modification	Minor; new hardware to meet new requirements	Extensive modification programs

agreements were legally binding and accountability was clear.

As a result of these considerations, major Soviet military development programs tended to be much more stable than U. S. military development programs (everything else held constant).

However, advances in electronics, computerization, information, and miniaturization since the 1970s left the Soviet military industry in a vulnerable position. The speed of change, the complexities of design, the integration of many different technologies and inputs from diverse sources, and the high precision and reliability needed in production struck at traditional weak points of the Soviet economy, which adversely affected Soviet military systems acquisition.

In the Soviet case, the central government dictated military system cost and schedule to a moderate extent (more so than performance). In addition, the buyer and seller, reporting to the central government, operated in an environment that "suggested" that they conform in part to the wishes of the central government. This was another force at work that led to incremental performance improvements unless the central government approved a program with considerably enhanced technology and/or performance. It reduced the absolute level of Soviet versus U. S. system performance in some cases, but then it also reduced the associated cost:performance (C:P) and schedule:performance (S:P) related program risk as well.

SOVIET AND U. S. ACQUISITION MICROECONOMIC CHARACTERISTICS

The key parties in Soviet military system development, production, and O&S phases were the Design Bureaus (development phase) and the relevant military service (user, O&S phase). The Design Bureau was analogous to U. S. defense contractors for the development phase, and the Soviet military service was equivalent to its U. S. counterparts for the O&S phase. As previously mentioned, there were no direct links between the military service, Ministry of Finance, and suppliers involved in the production phase. Thus, the relevant parties for microeconomic purposes in Soviet military systems acquisition were the Design Bureaus and the military service (In the military procurement case the buyer and the user can be treated as parties with identical preferences. However, this was not necessarily the case for civilian items where different preferences sometimes existed.)

On the surface this might seem to lead to a disjointed set of interactions between key parties. However, interactions did occur between the parties both directly and via the VPK during the entire military system lifetime. Thus, although the Design Bureaus and user interrelated in a somewhat different fashion and contained a different structure than in the corresponding U. S. case, both the Soviet and U. S. cases can be treated as bilateral cases between relevant parties representing the systems acquisition process.

The Design Bureau typically desired to increase development phase, hence life cycle, cost in order to insure full employment.

(The development phase cost was allowed to grow to a certain degree in order to meet performance and schedule requirements.) The Design Bureau also typically desired to decrease performance and increase schedule in order to have the highest probability to meet system design requirements. In effect, the Design Bureau attempted to minimize the risk of failure, not just for the development phase, but for the total system life cycle.

Given the typically greater disincentives for failure in the Soviet versus U. S. systems, there was a clear desire on the part of the Design Bureau to deliver what it promised. Pressure on the Design Bureau contributed in part to the relatively conservative design philosophy (compared to the U. S.) except in special cases where high technology (and risk) design solutions were necessary and authorized. This is in strong contrast to the U. S. case where, as stated by Charles J. Hitch and Roland N. McKean in 1960: "Excessive optimism in drawing up performance specifications can make the development so difficult that it must fail, or take much longer and cost much more than planned, or require a downgrading of the requirements. It is not unusual for weapon system requirements to be so optimistic that several inventions or advances in the state of the art are needed on schedule if the development is to succeed." [14]

The Soviet military service (user) typically desired decreased O&S and life cycle cost (in order to obtain a greater quantity of a given system), increased performance, and decreased schedule for similar reasons as the government in the U. S. systems acquisition case. The Soviet user also desired increased system reliability, and thus the associated increase in performance and decrease in O&S cost that accompanied it. (The Soviet user generally favored a trade involving lower operational performance for increased mission performance (reliability).)

In acquiring U. S. military systems, the government generally prefers lower over higher cost and schedule, and higher performance, while the contractor prefers higher cost, performance, and schedule.

Lower costs are desirable to the U. S. government to develop more military systems for a fixed budget (or the same number for a reduced expenditure). Shorter schedules that enable the system to become operational earlier enhance the force structure and military balance of power. Higher performance permits increased operational capability for the mission.

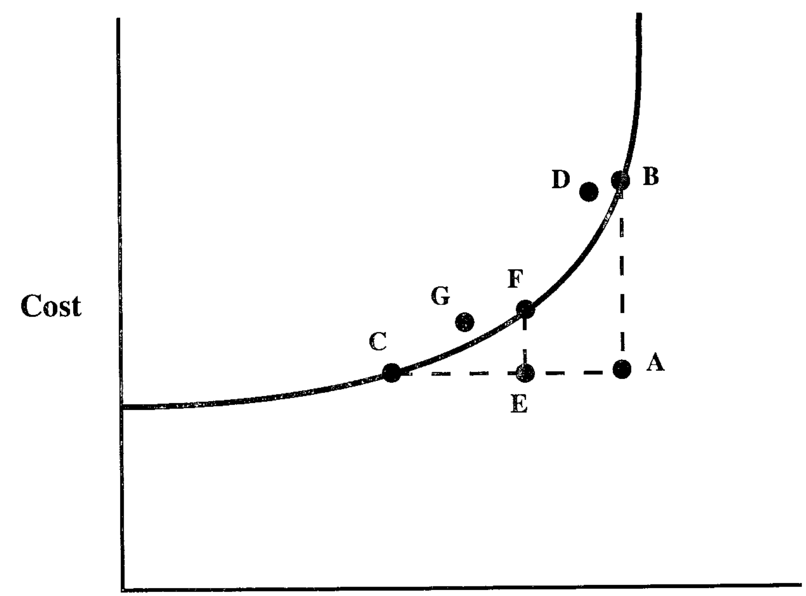
U. S. contractors prefer higher costs because they increase profits. Longer schedules are also desirable to maintain a stable work force and a long-term working relationship with the government, which gives the contractor a potential competitive advantage for follow-on or future contracts. Contractors prefer high performance to improve their potential competitive advantage in the high technology arena that often provides a potential competitive advantage.

In the Soviet case the user generally had in mind a maximum cost and schedule and a minimum performance level, while the Design Bureau had a maximum performance level and a minimum cost and schedule length.

In the U. S. case, the government will typically have in mind a maximum program cost and schedule length, along with a minimum performance level. The contractor will often have its own minimum cost and schedule length.

Typical Iso-Schedule U. S. Government and Contractor and Former Soviet Union User and Design Bureau Cost:Performance Technical Possibility Curve

Figure 1



Note: 1.) A and E = infeasible; B, F, and C = feasible, efficient; and D and G = feasible, inefficient solution points

2.) A, B, C, and D = possible U. S. government and contractor solution points

3.) E, F, C, and G = possible former Soviet Union user and design bureau solution points

4.) D = likely U. S. solution point in response to infeasible solution point A

5.) G = likely former Soviet Union solution point in response to infeasible solution point E

A technical possibility surface encompasses the region of feasible cost (C), performance (P), and schedule (S) solutions, and is the technical program constraint. Points on the technical possibility surface or any two-dimensional slice of the surface indicate efficient (but not necessarily optimal) solutions. (This is given by points B, F, and C on the C:P slice of the technical possibility surface (possibility curve) in Figure 1.) Points lying above a possibility curve indicate feasible, but inefficient solutions. Those points below a possibility curve indicate an infeasible solution.

In Figure 1 for the C:P case (for a given schedule), points D and G above the curve represent an inefficient combination of cost and performance, since the system could be developed at the same cost but with higher performance by moving to the right or at the same level of performance with less cost by moving down.

Points to the right of the C:P curve (A and E in Figure 1) are infeasible for a given set of input constraints (e.g., manufacturing processes, technology level, or program structure) for a given schedule. This point will only become feasible with a shift to the right of the entire C:P curve, thus requiring, for example, improved yield for a given manufacturing process if cost is held constant. In effect, solution points A and E correspond to an inappropriate schedule length selected for the specified cost and performance levels.

It is anticipated that the last few percent of the maximum performance possible will lead to increasingly greater program cost and schedule length (the first and second derivatives of cost with respect to performance are positive). This often causes a major problem in U. S. military systems acquisition where performance near or exceeding the current state of the art is typically specified for new development programs, yet insufficient cost and/or schedule is typically budgeted to achieve the desired level of performance.

Very large increases in unit cost can result in some instances as the performance state of the art is reached. (This corresponds to a solution point in the vertical portion of the C:P slice of the technical possibility surface (e.g., point B or above in Figure 1).) Such problems are not limited to military programs, affecting commercial technologies and programs as well. An exaggerated instance of cost increase for an extremely minor performance change is given as an illustration. Here, the purchase price of a relatively high performance U. S. commercial 1,389,580 detector element visible charge coupled device (CCD) focal plane array was examined. The only pricing criteria for the CCD is the number of defective detector elements, and as it goes from 20 to zero (for 1,389,580 total elements), the resulting price increases by a factor of twelve. Thus, the last 0.0014 percent of available normalized performance leads to a twelve times increase in cost, or 92 percent of the total cost!

Given a conservative and incremental acquisition strategy and design approach, the technical possibility surface was typically better known to a Soviet planner than to a U. S. planner. In effect, the Soviet user and Design Bureau did not typically push the desired level of performance to the steep portion of the C:P and S:P slices of the technical possibility surface as was more likely in the U. S. case. In addition, the Soviets historically achieved a relative degree of cost containment in many military systems by conservatively selecting the operating requirements, corresponding performance levels necessary to meet these

requirements, and system design characteristics.

Although it is not my intention to focus on the 1980-1987 period in this paper, during this time the prowess of the Soviet military acquisition process began to degrade versus the 1950-1980 period due to three reasons [2, 15]. First, the Design Bureaus began to realize that they had greater strength and faced fewer penalties than in the 1950-1980 period. Consequently, the dominance of the military service (buyer) began to fade and the bargaining power of the two entities began to shift. Second and similarly, the ability of the buyer to coordinate and motivate the Design Bureaus in a manner consistent with their desires began to diminish. These two reasons contributed to cost growth, performance degradation, and/or schedule slippage in some military systems deployed. Third, Soviet technology began to lag what was needed to support increasing performance requirements in a variety of Soviet military systems. This corresponds to solution points higher up on the C:P and S:P slices of the technical possibility surface, with higher potential levels of cost, schedule, and associated risk.

DISCUSSION AND CONCLUSIONS

Figure 1 illustrates typical Soviet and U. S. infeasible solution points and responses to these solution points in the C:P case. Given the more conservative and incremental Soviet acquisition strategy and design approach, infeasible Soviet solution points were likely to be closer to the C:P slice of the technical possibility surface than U. S. solution points for a given level of cost. In the Soviet and U. S. cases, the response to an infeasible solution point with respect to C:P typically ranged from maintaining performance and allowing cost to grow (points F and B) and maintaining cost and allowing performance to be reduced (point C). U. S. development phase C:P trade preferences usually strongly favor maintaining performance and increasing cost [1], as indicated by point D in Figure 1. In the Soviet case, a more balanced trade between performance and cost typically existed in response to an infeasible solution point, as indicated by point D in Figure 1.

The C:P slice of the technical possibility surface has positive first and second derivatives of cost with respect to performance (as shown in Figure 1). As the desired level of performance increases, the potential level of cost rapidly increases (for a constant schedule). In addition, the technical possibility surface is typically unknown during the course of the development phase. Consequently, slight miscalculations with respect to performance on the part of U. S. military system designers on average leads to a moderate level of development phase cost growth [1].

The level of U. S. development phase cost growth will likely be greater than in the Soviet case because U. S. C,P,S solution points typically have higher levels of performance coupled with the strong desire on the part of U. S. military system designers to maintain performance rather than trading cost, performance, and schedule in an unbiased fashion. This issue was first identified by Marshall and Meckling in 1959 [16], and is still applicable today: "Typically, in weapons development great emphasis is placed on performance. Most new weapons are developed around specific detailed performance requirements laid down by the military--requirements that are taken very seriously. The penalties incurred by the contractors for not meeting performance requirements are more severe than for failure to meet availability schedules or failure to

live within original cost estimates. As a result, whenever circumstances dictate a retreat from early plans, it is usually the costs and/or availability that gives ground."

The resulting solution region for historical Soviet military systems may be somewhat more stable and better defined (less uncertain) than for U. S. systems. This is in part because utility curve tangencies are possible in the typical Soviet C:S, C:P, and S:P cases, whereas they are only possible in the typical U. S. C:S case. (The direction of increasing utility for the Soviet user and Design Bureau were opposites in the C:S, C:P, and S:P cases, whereas this only occurred in the U. S. C:S case. This criteria is typically necessary to lead to tangencies for a given pair of goods (e.g., C:P). Only when tangencies are present can a pareto optimal contract curve exist, which may lead to a more stable solution region (all else held constant). However, the exact solution point achieved in such a case will depend upon the negotiating strengths of the two parties [17].)

In effect, historical Soviet military systems were typically not driven towards an infeasible solution region or programmatic boundary constraints as frequently as U. S. programs. In the U. S. case, no tangencies involving C:P and S:P will typically exist, and no forces are usually present to restrain movement of the corresponding development phase solution point towards increasing performance. This is because both U. S. government and contractor utility increase with increasing levels of performance. In addition, the resulting U. S. system development phase solution point may also be less efficient in a microeconomic sense than in the historical Soviet case. This is a result of preferences on the part of U. S. planners which is often towards relatively high performance systems and meeting performance requirements, rather than on trading C,P,S in a less biased fashion. Since C,P,S cannot be traded perfectly in the short-run, the cost and schedule levels that result from transforming an infeasible solution point to a feasible one are likely greater than the levels that could have been achieved for a given level of performance had the solution point initially been feasible (e.g., a more realistic budget and schedule).

However, for more complex Soviet military systems that encompass advanced technology and enhanced missions the potential advantage over the U. S. solution points in terms of stability and uncertainty was likely much smaller.

Both historically, and for more recent, complex military systems, the Soviet bargaining approach centers around the S:P utility and S:P slice of the technical possibility surface, with the corresponding C:S and C:P utility and slices typically less important. The S:P variable pair was favored because the decreasing order of preference for both the Soviet user and Design Bureaus in typical (and non-leading edge) military systems was for schedule, performance, and cost. High technology, hence high performance (leading edge) Soviet military systems often had a relaxed schedule in order to reduce overall program risk. In these cases the decreasing order of preference for both the Soviet user and Design Bureaus was for performance, schedule, and cost.

However, with rather conservative performance goals and design standards used for all but leading edge military systems, it was likely that the Soviets were able to achieve modest performance improvements in succeeding generations of systems, but with far less cost and schedule growth and variation than experienced in U. S. systems. This acquisition strategy was also

emphasized, and to a great extent enforced, by the risk mitigation strategies of both parties and the historically relatively greater bargaining strength of the user versus the Design Bureaus.

I will now briefly discuss some lessons learned from the Soviet military acquisition process that can likely be applied to the U. S. process to reduce cost and schedule growth. First, initial Soviet program performance requirements were made in a less biased fashion versus the anticipated level of program cost and schedule than in the U. S. Second, the resulting Soviet C,P,S solution point was generally more conservatively set than in the U. S. case, which led to reduced program risk and turbulence during the course of the program (everything else held constant). Feasible U. S. military system acquisition solution points can likely be achieved with moderately lower cost and schedule for only a small decrease in performance, given the typical infeasible solution point that initially exists. Third, there was likely less reluctance in the Soviet case to decrease performance during the course of the development program if the solution point appeared to be infeasible than in the U. S. case.

It is relatively easy to identify the cause of performance-related problems in the U. S. military systems acquisition process, and show how the level of such problems was likely far less in the Soviet acquisition process for typical programs. However, it will be much more difficult to create a paradigm shift to deal with performance-related problems in the U. S. case due to the underlying incentives that are inherent in the institutional structure.

Both Soviet and U. S. military acquisition programs have C,P,S risk due to an incorrectly specified technical possibility surface, which results from uncertainty in specifying the surface coupled with institutional biases and preferences. However, in the U. S. case, this coupled with the performance-related emphasis of both the government and contractors leads to moderate cost and schedule growth for typical U. S. military development programs.

The performance-related emphasis of the U. S. military systems acquisition process was identified by Charles J. Hitch and Roland N. McKean (1960, p. 252) in 1960: "Excessive optimism in drawing up performance specifications can make the development so difficult that it must fail, or take much longer and cost much more than planned, or require a downgrading of the requirements. It is not unusual for weapon system requirements to be so optimistic that several inventions or advances in the state of the art are needed on schedule if the development is to succeed."

The U. S. performance-related bias is compounded by government and contractor decision makers who are typically "graded" much more strictly on whether or not program performance objectives are met versus meeting cost and schedule objectives, as first identified by Marshall and Meckling in 1959 [16].

Placing equal or near equal emphasis on meeting program cost and schedule, as well as performance objectives, will be necessary in order to eliminate the strongly ingrained U. S. government and contractor program management bias favoring performance that has existed for at least the last 35 years in U.S. military systems. No appreciable change in U. S. program outcomes is likely to occur without a re-oriented C,P,S emphasis.

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DISCLAIMER

This paper is based upon independent research conducted by the author during 1981-1994. The views expressed are those of the author and not necessarily those of the United States government or any of its agencies.

THE COST/SCHEDULE CONTROL SYSTEMS CRITERIA AND ISO 9000

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ABSTRACT

The Department of Defense (DoD) has a unique approach to managing the performance of its suppliers, codified in a management standard entitled the Cost/Schedule Control Systems Criteria. I will explore the hypothesis that the DoD approach is actually a quality management model that fits within the guidelines of the international quality standard ISO 9000. This has interesting implications given the current emphasis within DoD on acquisition streamlining and use of commercial practices.

INTRODUCTION

The Cost/Schedule Control Systems Criteria and ISO 9000

The Department of Defense (DoD) has a unique approach to managing the performance of its suppliers, one that is gaining increased respect inside and outside the DoD as a highly useful program management tool. The DoD approach is codified in a set of management standards called the Cost/Schedule Control Systems Criteria (C/SCSC). I hypothesize that the C/SCSC are in fact a quality management model that fit the international quality standard ISO 9000. I propose that the DoD consider seeking ISO 9000 certification for the C/SCSC or some sort of reciprocity agreement on use of the C/SCSC to satisfy the management guidelines of ISO 9000.

To explore my hypothesis, I will highlight the key precepts of the C/SCSC, the key management precepts incorporated in ISO 9000, and compare and contrast the two models. This analysis will make the case that the C/SCSC are actually a quality management model. I will conclude by exploring possible approaches the DoD might consider to integrate the C/SCSC with the ISO 9000 commercial practice.

ISO 9000 and the C/SCSC: A Comparison

DoD has recently embraced the international quality standard ISO 9000. In February 1994 the DoD authorized the use of ISO 9000 in contracts for new programs (McGovern, 1994). DoD has used the C/SCSC as a contractor performance management approach since 1967. Both ISO 9000 and the C/SCSC are standards for running a business well. They are is designed to apply to any product or service made by any process anywhere. In order to be this generic, both refrain from mandating specific methods or techniques, leaving these choices up to the business managers. Both ISO 9000 and the C/SCSC require businesses to document their own management procedures. ISO 9000 requires a business to manage in accordance with its own documented procedures, as long as they meet the basic requirements of the standard (Rabbitt and Bergh, 1994, pages 9-10). The C/SCSC require a "system description" that

describes the management system and explains how it meets the standards. ISO 9000 requires that all activities affecting quality must planned, controlled and documented The main requirement of the C/SCSC is to build a "performance measurement baseline", which is simply a formal documentation of the processes required to deliver under the contract in question. Controlling the performance measurement baseline so that costs and quality remain within plan is also a key requirement of the C/SCSC. The main difference between ISO 9000 and other quality schemes like TQM is that a firm can register to ISO 9000 after an accredited third-party registration body certifies that the firm's quality system conforms to the standard (Johnson, 1993). This registration has important implications for a firm's competitiveness, and firms are registering with ISO 9000 in record numbers for this reason. Firms doing significant enough business with the DoD to require the application of the C/SCSC to their management system must submit to an audit by DoD. The intent of the audit is to certify the firm's system as compliant with the standard. With the C/SCSC, as with ISO 9000, certification has implications for the firm's competitiveness. The similarities just shown between ISO 9000 and the C/SCSC are striking.

The ISO 9000 series consists of five core standards: three quality assurance models for specific environment and two documents that give general guidelines. A simple way to capture the interrelationships of the documents that comprise the ISO 9000 standard is to depict them in a diagram, as below (Gower, 1993, p.30):

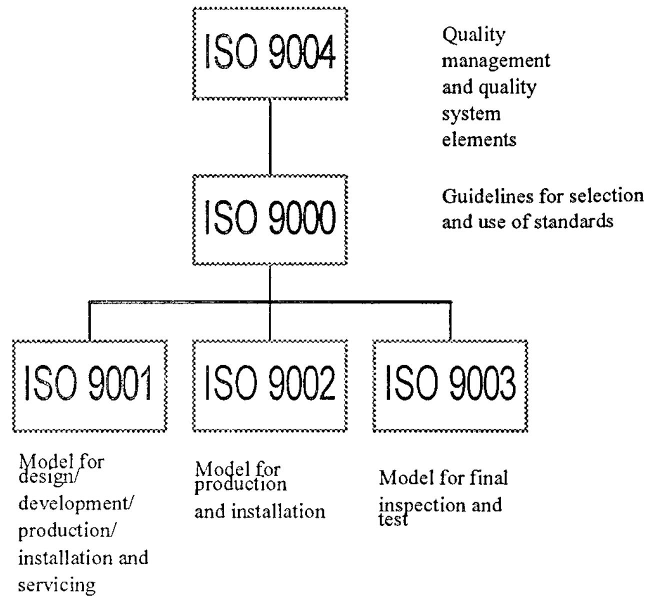

Figure 1

Upon closer inspection the ISO standard that is most similar to the C/SCSC is ISO 9004, which gives guidelines for quality management and quality systems (American Society for Quality Control, 1987). The following is a breakdown of the ISO 9004 elements, with discussion of how the C/SCSC deal with the same element indicated in italics. This discussion draws on the 1987 American National Standard Q94, which is the American version of ISO 9004, addressing Quality Management and Quality System Elements.

ISO 9000 states that, in order to be successful, a company must offer goods or services that satisfy customer expectations at a cost that will yield a profit at competitive prices (American Society for Quality Control, 1987, p 1). *The C/SCSC are a clear definition of DoD customer expectations, and one of their key purposes is to insure that DoD obtains a service or*

product at as competitive a price as possible. The C/SCSC normally only apply when DoD flexibly prices its contracts, which it does in order to offer reasonable profit incentives to companies in the high risk environment of DoD contracts. Again, there are strong similarities between ISO 9004 and the C/SCSC.

The ISO 9000 mentions that the scope and field of applicability of the standard depend on factors such as market being served, nature of product, production processes, and consumer needs (American Society for Quality Control, 1987, p 2). *A discussion of the DoD market and nature of the product DoD buys will show clearly that the C/SCSC are simply standards well adapted for the DoD market and nature of product.. At one extreme of the spectrum of possible markets is the truly competitive market. In a truly competitive market, there are many sellers and buyers selling a homogeneous product, so the invisible forces of the market set the best price and quality. Customers can rely on the market price being the best price available for the best quality product. They should not need insight into a suppliers' internal performance data to help them determine the right price. The suppliers need performance measurement systems in order to remain competitive, but the customer can rely on market price as an indicator of value. The less competitive a market, the less the customer can rely on the invisible forces of the market to set a good price for a good quality product. The proliferation of ISO 9000 registered firms is a sign that customers cannot strictly rely on market price, but are looking for other assurances of product quality and price. DoD often buys in a non-competitive market. For instance, DoD buys weapon systems still in the conceptual phase or research and development phase, where there is no similar product in existence and the technical risk is so high that it is difficult to know what the system will cost. DoD may be the only buyer of such a system. Furthermore, there may only be a few or even just one seller. In such a market, there are no invisible market forces that set price. Instead, the contracting parties negotiate estimated prices and resort to using flexibly priced contracts to share the cost risk. In a flexibly priced contract, the price the government pays will vary depending on the suppliers' actual costs to perform. This contracting practice places much cost risk on the government, which it attempts to mitigate by requiring insight into internal contractor performance management. If the DoD is not satisfied with a contractor's progress, it can take early management action to terminate the contract and limit its losses. DoD has been a pioneer in the area of contractor performance measurement via standards, probably because of the high risk nature of its market. The DoD has been using the C/SCSC since 1967, whereas the commercial world adopted the ISO 9000 standard in 1987 with recent growth in number of registrations fueled by international competitive pressures (Rabbitt and Bergh, 1994, p 9.).* The C/SCSC are standards for management that are particularly well suited to the DoD market and nature of product DoD buys, and as such the C/SCSC conform to the requirements of ISO 9004.

Section 4 of ISO 9004 addresses management responsibility. It states that the responsibility for and commitment to a quality policy belongs to the highest level of management, that there should be a documented quality policy with defined

objectives pertaining to key elements of quality. It further states that management should develop and implement a quality system that insures satisfaction of customer requirements and emphasizes problem prevention (American Society for Quality Control, 1987, pages 2-3). *The C/SCSC require involvement at the highest program management levels, a documented policy with defined objectives such as variance thresholds and completion of the contract on time and within negotiated contract cost. The emphasis is on problem prevention early through a good management control loop.* In this area, again, the C/SCSC conform to the ISO 9000.

ISO 9004 requires clear identification of general and specific responsibilities and authority. The organizational structure and lines of authority should be clear (American Society for Quality Control, 1987, p 5).. *The C/SCSC subsection entitled Organization deals with the same issues.*

ISO 9004 requires management to provide sufficient and appropriate resources to achieve quality objectives (American Society for Quality Control, 1987, p 5). *The C/SCSC subsection entitled Planning and Budgeting deals with the allocation of resources in accordance with the company's need to produce the good or service at a given price in an agreed to period of time and meeting the quality specifications of the contract.*

ISO 9004 requires that the quality system allow adequate and continuous control over all activities affecting quality. The management system should emphasize preventive actions and allow the ability to correct failures should they occur. Written procedures that state simply, unambiguously, and understandably the methods to be used in management control should exist (American Society for Quality Control, 1987, p 5). *The C/SCSC focus on control of processes or activities necessary to deliver the product or service. The entire concept of building a performance measurement baseline, which is at the heart of the Planning and Budgeting Section of the C/SCSC, has to do with setting up a baseline for management control. The Analysis section of the C/SCSC then deals with the actual control process, namely the identification of problems and the need to take and document remedial action.* Here again, the C/SCSC and the ISO 9000 are in agreement.

The ISO 9004 devotes a number of paragraphs to the need to document procedures. *This too is an integral part of the C/SCSC. A C/SCSC compliant management system must have a written system description and managers at key control points must maintain a document flow.* Documentation is essential for proper audit of the system, which ISO 9004 states is an essential part of a management system. ISO 9004 requires regular internal audits and a written audit plan formulated by company management (American Society for Quality Control, 1987, p 6). *The C/SCSC require regular internal audit, though traditionally this has been done by an agency outside the company, namely the cognizant government contract administration office. The trend in DoD now is toward internal company "self-surveillance."*

After the above general topics, ISO 9004 moves to more specific areas such as quality in marketing, specification and design, procurement, and production. The C/SCSC are not this specific because they

are not designed, as ISO 9004 is, to be integrated with another, much more specific standard like ISO 9001, 9002, or 9003. However, the issue of control of nonconformity and corrective action is an integral part of all the ISO 9004 areas. For instance, ISO 9004 discusses corrective action in detail. It states that it is necessary to define the responsibility and authority for instituting corrective action and that management should evaluate the importance of problems, investigate causes, and take corrective action (American Society for Quality Control, 1987, pages 6-15). *This is a key element of the C/SCSC standard, with the requirement to identify who the "cost account managers" are. The cost account managers are the managers responsible for instituting corrective action.*

The similarities between ISO 9004 and the C/SCSC are remarkable. To make them just a bit clearer, it may help to place ISO 9000 into its place in the overall quality spectrum and then compare how the C/SCSC fit in this spectrum as well. Many different quality experts have approached the subject from slightly different angles, but there are common threads. One author has distilled the quality issue down to seven critical factors for business success:

1. Customer focus
2. Process versus results focus
3. Management commitment/responsibility
4. Continuous improvement
5. Less than 20% of problems caused by workers
6. Performance measures
7. Cross functional councils create constancy

This author contends that ISO 9000 addresses the first three factors, that it is at the very basic end of the quality evolution, with Total Quality Control and Total Quality Management at the mature end of the quality evolution (Rabbitt and Bergh, 1994, p 21-24). I would add to this that I have demonstrated that the C/SCSC address these first three, as well as focus 6. The C/SCSC specify a particular performance measurement technique called **earned value.** A comparison of the C/SCSC with the Total Quality Management (TQM) that Deming espoused will help to clarify the position of the C/SCSC in the quality spectrum.

TQM and C/SCSC --A Comparison

Let's start with the top level desired outcome or strategic objective of TQM and the C/SCSC. The desired outcome of TQM is a quality product or service produced at the lowest cost and meeting the expectations of customers. This is strictly in agreement with the ISO 9004, which we have already shown the C/SCSC to conform to as well. Thus, ISO 9000, TQM and C/SCSC have a common strategic objective, as you would expect of elements in a general quality spectrum (Rabbitt and Bergh, 1994, p 24).

In order to achieve their objectives, TQM and C/SCSC each defines a strategy. TQM embraces a philosophy of **continual improvement in processes,** to be achieved through a **Plan-Do-Check-Act** process. The focus on **continual process improvement** is not an implicit requirement of the C/SCSC, as it is not with ISO 9000. Continuous improvement is a mindset that is at the higher end of the quality evolution (Rabbitt and Bergh, 1994, p 24). In common with TQM, however, the focus of C/SCSC is on baseline processes, and on improvement to the

processes in order to keep costs under control. To clarify the commonality of C/SCSC and TQM, it is useful to break the C/SCSC and the TQM down as a **Plan-Do-Check-Act** management model (Conway, 1993). This analysis will show that the C/SCSC are a formal version of a **Plan-Do-Check-Act** TQM management process. The C/SCSC names for **Plan-Do-Check-Act** are ***Organization, Planning and Budgeting, Accounting, Analysis, Revisions.***

In the **Plan** phase management identifies the baseline processes, customer needs, and products. With a baseline, it is possible to measure improvements in existing processes and through incremental improvements succeed at delivering a product that better matches customer needs. Upon close examination we find that the ***Organization and Planning and Budgeting*** sections of the C/SCSC deal precisely with the **PLAN** step. These sections address the need for management to identify processes that result in products, as well as to identify managers responsible for the products. The products are defined in the work breakdown structure, and the processes are documented in a performance measurement baseline.

The **Do** phase is the phase in which management takes the first step to continual improvement of the processes documented in the plan phase. In the **Do** phase, the organization puts the plan into action and collects data on the activities. In the **Check** phase, management analyzes results from the **Do** phase, makes comparisons with expected results, and attempts to gain a clear understanding of the causes of the results. This is also the phase in which management identifies process improvements. In order to make meaningful continual process improvements, it is essential to measure performance of the baseline processes meaningfully. If the measurement metric is not a meaningful measure of performance, process improvements proposed based on analysis of that metric are likely to be off the mark. Performance measurement metrics are the subject of numerous books. The measurement technique often associated with TQM is statistical process control, but there are many different performance techniques. The trick is to choose the most appropriate performance measurement technique to measure each process. The **Act** phase is the final step in the cycle. In this step, the organization institutionalizes the improvements identified in the **Check** phase

The ***Analysis*** section of the C/SCSC addresses the **Do-Check-Act** phases of the TQM. The C/SCSC require rigorous assessment of reasons for deviation from plan, impacts on the product, and methods for recovery or process improvement if there is a significant deviation from plan. Just as with TQM, the choice of the right performance measurement technique is crucial to the success of the management process. In the case of the C/SCSC, there is a requirement to use earned value or Budgeted Cost of Work Performed as a performance measurement technique. This technique is particularly well suited to the DoD market, but it is simply a performance measurement technique.

With the completion of the **Act** phase, the management cycle starts over. The baseline plan now incorporates the process improvements identified in the previous cycle, and any future improvements will build on those that have been institutionalized (Conway, 1993).

The foregoing comparison makes the essential link between C/SCSC and TQM clear. C/SCSC terminology may obscure the link. For instance, the remaining sections of the C/SCSC, ***Accounting and Revisions***, deal mainly with the discipline of the **Plan-Do-Check-Act** or performance measurement system. In the TQM model, these subjects do not have equal standing with **Plan-Do-Check-Act,** which are the key management processes. In the C/SCSC these sections receive equal standing with the key management processes. The author understands that the C/SCSC joint implementation guide, currently in revision, takes a management process orientation.

This comparison places the C/SCSC into its place in the overall quality spectrum. **Armed with** the foregoing analysis, it is now possible to consider in an informed manner how the DoD might integrate the C/SCSC with the ISO 9000 standard.

Why Not Have an International Standard for C/SCSC Similar to the International Quality Standard?

The foregoing analysis has placed the C/SCSC in its place in the quality spectrum and shown the similarity between the C/SCSC and ISO 9004, the management piece of the ISO 9000. The DoD has already adopted ISO 9000 overall as an acceptable quality management standard. If you accept the argument that the C/SCSC are basically a DoD version of ISO 9004, tailored to the unique needs of the DoD market and product, it makes sense to seek formal recognition of this link. The defense industry is familiar with the C/SCSC approach, ISO 9000 is making growing inroads into the commercial world, and the DoD is currently focusing on maximum use of commercial practices. There are many approaches the DoD might pursue, but one that comes to mind from the foregoing analysis is to seek recognition of the C/SCSC as a form of ISO 9004. This would allow a C/SCSC certified company to use the C/SCSC certification as proof of an acceptable overall management process, with the applicable ISO 9000 standard insuring it has an acceptable quality process in place.

CONCLUSION

This article explored the hypothesis that the DoD contractor performance management approach embodied in the C/SCSC is a quality management model that meets the intent of ISO 9004. The methodology of comparative analysis showed the similarities between ISO 9000 and the C/SCSC. **Considering** this analysis, the article recommended that the DoD seek some kind of recognition that the C/SCSC are ISO 9004 like management guidelines.

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A Model To Determine the Unit Cost of Procurement Actions

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ABSTRACT

In 1991 Defense Management Report Decision Number 971 proposed that the Defense Business Operating Fund (DBOF) be implemented by specific Department of Defense (DOD) activities. The initiative required that activities identify the cost of providing services to their customers and charge their customers for those services. An operating fund would be created to provide financial support for the organization at the level in which it operated. The operating fund concept is intended to impart to each activity the sense of operating in a business or competitive environment. The lack of a competitive environment often has been cited as a major inhibitor to real improvement in performance and in controlling costs in the public sector. In anticipation of implementation of such a policy, the Contracts Department at the Naval Air Warfare Center Weapons Division (NAWCWPNS) China Lake, Calif., began to develop, test, and implement the unit cost concept.

Within NAWCWPNS the Contracts Department has been operated and funded as a general and administrative (G&A) organization. At the beginning of the project, the Contracts Department had little quantitative data to indicate procurement costs to process individual requirement actions, total output by the workforce, or effectiveness of the operations. Department personnel were not expected to perform to specific quantitative standards for processing. Consequently, procurement officials had little incentive to streamline processes for greater efficiency. The intention of the Unit Cost Model (UCM) project was to provide information that would provide standards and measurement capability to support process improvements, as well as fulfill the requirements of the DBOF initiative.

Early in the development phase we were introduced to the Systems Thinking concept, which encourages viewing a system as a whole to understand its behavior as a method of creating better solutions. Unwanted consequences can be predicted through model simulation of the system. Effective solutions may include the lessons learned through modeling. We used Systems Thinking tools in the development of the UCM to consider the effects of various choices by the customer and outside activities as relates to the complexity of the requirement. The predicted cost and direct processing time to execute a procurement action are based on the total complexity weighting.

The model provides the customer with cost and schedule information about the proposed procurement. The cost estimate will vary depending on the level of customer service required, and the amount of lead time available. The model also provides the Contracts Deaprtment with standards to measure its performance.

This paper addresses the methodologies used to conceptualize and develop the UCM, implementation of the model, and the resulting changes in Procurement Department operations.

INTRODUCTION

From 1985 to 1990 the Procurement Department at China Lake went through a cultural change from a traditionally managed procurement shop—part of a Naval Supply Department—to a more open and innovative culture where workers were empowered. One method of empowering workers was through their participation in Procurement Improvement Action Teams, or "Impact" Teams. These teams were chartered by the Executive Steering Group of the Contracts Department to identify systemic problems and provide the mechanisms for process improvement. Among those teams chartered was the Workload Management Impact Team (WIT), which was tasked with the responsibility of identifying a method to measure workload. Specifically, the team was to quantify the

complexity of both preaward and contract administration work, so that a comprehensive and fair comparison of all work could be made beyond simple numbers of actions and estimated dollar value of the actions.

The systemic problem that necessitated the forming of this team was the consistent inability of department managers to agree on workload and allocation of resources for adequate support. The Contracts Department was composed of branches that supported finite customer groups. Shifts in workload, due to changing levels of support required for various weapon programs, presented a tough choice for procurement managers regarding shift in personnel or reallocation of customers and accompanying workload to provide an improved level of customer support.

Before the creation of the WIT, management agreement on the amount of work-in-process for both new contract actions and contract administration was difficult to achieve. Managers with a high count in terms of actions tended to refer to those numbers, while managers who provided support to programs with a smaller number of complex actions generally pointed to the amount of effort required for support. Managers became aware that some sort of consistent method to measure work must be identified. As far as contract administration, managers often described the workload in terms of "we have a lot." At the time no automated system existed to provide a count of ongoing contract administration actions.

The advent of the DBOF initiative during fiscal year 1992 focused our concerns about how well our processes really worked, given that we experienced such great variation in procurement administrative lead time (PALT) for new contract actions. At the time we were faced with an increasing widespread geographical area of operations. The research, development, test, and evaluation facility at China Lake had consolidated with four other sites earlier in the year, with the new NAWCWPNS spread across a region from New Mexico to Hawaii. As a result of these influences, our efforts became concentrated on measurement as a means of understanding our costs and improving our processes. As DBOF specifically required that an organization know its output of products and what each product cost, the concept of a UCM began to take shape.

INITIAL TASK PARAMETERS

The initial concept development tasks were direction to use the product of the WIT, allocation of the cost over the PALT, and the concept of a variable rate of customer service. The resulting model was to have a three-dimensional appearance, with the three specified areas serving as axes.

Can Cost Be Measured Per Day?

Because I had served on the WIT and played a role in development of its product, I addressed the PALT portion of the model first. After several days of calculating the mean and standard deviation of PALT for the awards found within each of the specified dollar thresholds, I realized that allocating costs based on the number of days required to process and award a new requirement could not be accomplished. Our internal processes were so out of control, in the total quality management sense, that any determination of the PALT associated with the particular features of the requirement had variances up to 50% of the mean. Any attempt to access costs on this basis would be grossly unfair to the individual customer. The other reservation I had about accessing costs on the basis of cost-per-day of lead time incurred was that this concept was similar to a cost-as-a-percentage-of-cost contract. In theory the more days the Procurement Department spent in the solicitation, negotiation, and awarding of a requirement, the greater the cost to the customer. This approach would actively work against the goal of providing incentives for process improvement. The only prospect of coming up with a credible approach was to develop an hourly rate, and estimate the number of hours required in the processing and execution of each type of procurement action. In the procurement world this concept would be considered an engineering estimate, not generally considered the preferred method for estimating costs.

This project would have been assisted immensely by the existence of a capable management information system, but only a limited system was in place. The Procurement Department at NAWCWPNS, like many other government activities, primarily measures and records that information required for reporting outside the department. All the output of services provided by the department is not recorded or known. The budget requirements for a G&A-funded department do not require an in-depth understanding of the nature of expenses and revenue.

Customer Service

To add a cost for customer service, the various levels of customer service had to be defined. In attacking the problem, I divided customer service into two components. From past experience as a contract specialist, I realized that part of the customer service provided was based on the complexity of the requirement, and the remainder was due to the preferences and needs of the customer. In keeping with the overall pricing strategy, the first level was called Basic Processing, which represents a zero level of customer service. This level was offered not for its desirability but rather because a baseline representing no premium cost had to be included to be comparable with other organizations that had no customer focus. Three levels were delineated between Basic Processing and the highest level, Level 4 Service, representing the world-class customer service we often provide to major program offices. Level 4 Service probably would be indicated by anticipation of travel with the customer, support for program office briefings, meetings with sponsors, and perhaps participation on a team with the customer to assist in writing the acquisition requirements package before it is brought into the procurement office for processing.

Customer services related to the complexity of the requirement are at the following levels and definitions:

- commercial or part numbered item, 0% premium effort
- fixed-price noncommercial supply requirement, 2% premium effort
- time and material or fixed-price services, 5% premium effort
- research, development, test, and evaluation requirement, 8% premium effort
- competitive service requirement featuring cost realism analysis, 10% premium over basic processing.

The customer service costs associated with the complexity of the requirement are non-negotiable cost items. The desired levels are somewhat at the discretion of the customer. Even though five levels of desired customer service are featured, we recommend that service below Level 2 will most likely not meet customer needs. Basic Processing and Level 1 Service may end up costing the customer more in time for evaluation, negotiation, delays, and/or contract administration effort than the higher level of customer service. Mid-level service, Level 2, is the minimum level of customer service we provide at our activity.

Except for the initial level denoting no customer service, each level for desired customer service is identified by a number. Briefing contract specialists on the project and identifying the levels with descriptive titles, such as minimum level of service, high level of service, brought some angry responses by individuals refusing to consider downgrading the customer service provided from the world-class level. However, whether we choose to acknowledge it or not, we currently informally ration the customer service we provide, based on priorities, visibility, and other factors. By negotiating the level of service with the customer up front, we can establish a contract where the service is based on the requirement complexity and other factors, and on how much the customer is willing to pay. Until our department culture can transfer the notion of price allocation of service, the assignment of numbers to differentiate between the levels of desired service seems more acceptable to the workforce.

Complexity as a Price Determinant

Complexity, as determined by the WIT, is the feature that provides the primary deter-

mination of the cost to the customer. Each requirement is assigned a complexity weighting based on the dollar range applicable to the Government estimate of the cost of the requirement, the type of contract, and other features, including solicitation by means other than full and open competition (OTF&OC), using best value method of source selection or planning a presolicitation/ preproposal conference. Weighting for the estimated cost of the procurement action is based on significant acquisition dollar thresholds ($50K, $500K, $1M, $10M, and $50M) where the value of the procurement imposes added complexity in processing of the requirement. In selecting attributes for the assignment of complexity weighting, the WIT was not attempting to measure the effort for the individual feature but the complexity present in the whole process when the specific feature was present. For example, having a preproposal conference may not take a lot of effort in and of itself, but these conferences are not generally held unless complicating factors are present in the acquisition, signaling increased efforts throughout the procurement processing.

After the complexity weighting is determined, the weighting is multiplied by the number of basic hours allocated for the type of instrument being processed. An adjustment is made for any split or other award made from a Broad Agency Announcement where only one solicitation is written or an oral solicitation is used rather than the normal written solicitation. The product is the number of net direct hours expected to be spent directly processing the requirement. On top of the direct hours is added a factor for time spent on process improvement, time for travel in support of technical requirements (an opportunity cost because the individual cannot work on other requirements to generate revenue), and a factor for training.

DOD has an extensive program of mandatory training for acquisition personnel. The number of changes affecting the acquisition field in the last few years has increased the amount of refresher training employees must engage in to maintain effective skills in the profession. The training received typically provides benefits to all customers not just a select few. For this reason, a factor to recoup the costs among all customers for time spent receiving training is a necessary part of operations.

The final factor for determination of the number of total hours required is the amount of customer service determined by procurement and technical personnel to be appropriate for the acquisition. Multiplication of all the indirect factors by the number of net direct hours, plus the number of net direct hours, equals the total number of hours.

The average hourly rate for contract specialists and procurement technicians is applied to the total number of hours for direct personnel, as is the hourly rate for all department indirect support personnel and non-labor costs. Indirect labor costs include the labor for contracting officers, clerical staff, supervisors, analysts, administrative officers, department management, and contract management advisors (CMAs) who serve as liaison officials in support of the technical customer. Contracting officers were not included in the direct labor costs because the majority of their time is spent on efforts of general support benefiting all present and future work, as opposed to particular ongoing actions. CMAs are included in indirect labor because no comparison with other contracting activities is possible. This function generally does not occur within most contracting organizations other than at NAWCWPNS. The direct efforts performed by CMAs occur before acceptance and processing by the Contracts Department and represent only a portion of their function, with the remaining duties clearly representing indirect activity. Non-labor costs include budgeted expenses for equipment purchase, contracts, travel for Contracts Department personnel, supplies, utilities, transfer payments to other departments, and costs associated with purchases and depreciation of federal information processing (FIP) equipment. The total represents the estimate of all operating costs based on the expected share of the total workload represented by the requirement.

USING PRICING FEATURES TO INFLUENCE DEMAND AND OTHER PRICE ADJUSTMENTS

Customer Discounts

Customer demand for government procurement services typically peaks the last half of the fiscal year, primarily because of the long lead time associated with funding of requirements. The imbalance of incoming workload favors longer lead times in the beginning of the fiscal year and mistakes in the latter half as personnel are pressured by too many demands.

In establishing the cost structure of the UCM, our goal was to establish a pricing mechanism within the NAWCWPNS acqui-sition community to introduce the dynamics of a competitive market. This policy implementation is in stark contrast to the sole-source bureaucratic environment that traditionally influenced contracting organizations in inefficiently implementing processes. We believed that the best way to implement process improvements to cut costs and provide better service to our customers was to train ourselves to view our situation as being in competition for customers and as a business base within a market.

We recognized that as consumers we react individually to price incentives. We took the concept one step further by projecting that individual customers or program offices would attempt to maximize their budgets by submitting requirements early when possible if offered financial incentives to do so. In this way we are attempting to manage demand for our services, so that we can move more of the requirement entering the procurement service queue into the first quarter of the fiscal year. During the first quarter of the year, the department experiences the most excess capacity in resources. Reducing excess capacity in the organization in the early part of the fiscal year promotes effective operations with fewer personnel. Currently, the Procurement Department must be staffed to meet the workload bulge during the latter half of the fiscal year, because we can't easily reduce or increase our workforce according to workload. By using the pricing mechanism as an incentive for early submission of requirements where possible, we encourage a greater stabilization of workload for the year.

Premium Pay

When our customers fail to meet the prescribed submission dates for guaranteed award in the same fiscal year and the customer desires the requirement be awarded by the end of the fiscal year, premium pay will be charged to that customer. This concept represents an important difference between the number of days required to award a new contract and the number of hours required to process. In most cases our customers do not realize that we must perform the same processing for actions whether we have plenty of lead time or not. To eliminate process bottlenecks the contract specialist often must hand carry, fax, or otherwise use extraordinary administrative procedures to influence the speed at which the requirement is processed. The contract specialist normally can work on other requirements while reviews are being made. However, when the available lead time is insufficient, the contract specialist often must accompany the requirement while reviews are made. This represents an inefficient use of labor resources and sometimes requires overtime to ensure that actions are accomplished by the deadline quoted. All the customer realizes is that the requirement was awarded in a shorter amount of time than usual. By charging premium pay, the customers will begin to gain a better understanding of the role they play and of our processes.

Premium pay is used to provide incentive to the customer to submit requirements within the published lead times for the indicated dollar thresholds of the requirements. Charging premium pay for requirements submitted late in the fiscal year, those normally accepted on a "best efforts" basis, also educates the customer that these requirements may be awarded with less PALT days. But the number of hours required for processing is often greater because a number of processes require hands-on processing to work through organizational bottlenecks, for example, walking documentation through for approval to obtain legal reviews, review by

senior procurement officials before negotiation and award, and faxes sent to contractors.

Service Rebates

Charging a premium rate for failing to submit a requirement within administrative deadlines that represent lengthy processes outside statistical process controls is not entirely fair to the customer. In many cases at the point in the program when the need is realized, the customer is already beyond the submission deadline necessary to obtain delivery without experiencing program delays. We recognize that procurement officials must work in partnership with their customers and accept part of the risk in acquisition. Therefore, providing a rebate to the customer would be appropriate only when the upper range of the lead time is exceeded by the Contracts Department. If award is not made timely, the program manager experiences greater program risk, but the Contracts Department also experiences an operating loss on the contract action and increases its overall financial risk.

INFORMATION FROM MODEL OUTPUT

When a customer provides the Procurement Department with information describing a proposed acquisition, what type of information might that customer expect to receive from entry of descriptive data into the UCM? The major information available for a new contract action is as follows:

Total Adjusted Preaward Contract Cost: Includes all labor and non-labor costs, and adjustments for required award date. If a rebate or discount to the customer is included, this cost is not equivalent to the total cost to process. This cost represents the cost charged to the customer.

Contract Complexity Weighting: Allows a comparison of complexity of customer's requirement in relation to other requirements.

Total Hours: Number of hours of direct personnel attributed to processing the defined requirement, plus other indirect hours. Also represents the number of hours used as a multiplier against the indirect labor and non-labor hourly rates to determine their contributions to the total cost.

Basic Hours: Base number of hours for the type of contractual instrument required or planned.

Predicted PALT and the Low and Upper Range: Provides the customer with the predicted administrative lead time, and the upper and lower range representing best-case and worst-case scenarios based on the complexity characteristics of the requirement.

Total Fixed and Variable Costs: Subsets of the total adjusted preaward contract cost.

Total Adjusted Direct Labor, Indirect Labor, and Non-Labor Costs: Subsets of the total adjusted preaward contract cost.

Net Cost For Required Award Date Adjustment: Adjustment for premium pay or a discount to the customer, reflected as a negative number, for early submission of the requirement. Included in the total adjusted preaward contract cost.

Cost of Customer Service: Customer can see the cost of customer service as they have defined it, allowing variation in the level to be entered to ultimately determine the best trade-off of service to meet budget and program needs. A subset of the total adjusted preaward contract cost.

Net Direct Hours: Estimated number of direct processing hours required to provide the described service.

Total Contract Instrument Award Cost: Cost exclusive of any rebates or discounts to the customer. This cost represents the true cost to process a requirement and may or may not be equal to the cost charged to the customer.

To demonstrate how the existence of information from the UCM can assist contract specialists and contracting officers, a comparison of the costs to issue a $200,000 delivery order under a General Services Administration schedule versus a contract

valued at $200,000 shows the GSA order costs $2959.59, while the contract costs a minimum of $18,086.40. Providing the administrative cost to process an action can lend support to ensure decisions are made in the best interests of the Government.

THE CHALLENGE TO INCLUDE ALL OPERATING COSTS

In typical government operations, identifying the true cost of a service is almost impossible. Unlike the private sector, most public sector services are "free" to the customer. Even government internal service, which has a visible cost, usually concentrates on the direct labor furnished for a project. Not only was there a dearth of information within our own department regarding operations performance and costs, but also within the established budget and finance organizations. Many of the costs were not known because, at least for the organization in question, the costs did not exist as an actual cost of business.

The first challenge was to identify all labor costs through forecasts of workload for the coming year. Year-end workload reports are reviewed for total awards in each workload category, as well as the net change of work-in-process for new contract awards. The totals are adjusted based on market conditions to determine what type of work will be coming in and in what number. An example of an adjustment we made is in contract administration. With NAWCWPNS experiencing a decrease in overall funding, many customers find they must downscope research and development or service contracts. Delays in receipt of funds or otherwise stretching efforts cause greater efforts to be devoted to contract administration. For this reason adjustments have been made to increase the amount of time required for basic contract administration and in forecasting the number of modifications.

A model was created to calculate the amount of labor required to process each type of service provided based on its estimated number and amount of labor required for each category for the coming year. Included was contract administration, contract close-out, and issuance of delivery orders against indefinite delivery—indefinite quantity contracts. After forecasting the expected level of workload for each category of complexity, the data are input in the "control panel," and the model is run to compare the number of direct personnel required to perform the workload versus the number of personnel on staff available to provide the services. The amount of labor required to provide the estimated services is calculated as a percent of labor utilization—the percent of the whole used to generate revenue for the organization.

That percentage of the direct personnel not earning revenue for the organization must be passed along as an indirect cost to all customers providing revenue. Each calculation of direct hours is then divided by the labor utilization factor to determine the number of hours the customer must fund for the department to meet the revenue objective. The number of hours was used as the data field to be manipulated, rather than labor and non-labor costs per hour, because it was important for the rate of individual costs to be visible. Maintaining the same costs per hour and simply identifying additional hours as net non-revenue-generating hours provided the same visibility to elements of costs, as well as granting visibility to the under utilization of labor.

Another cost recently included in the UCM was the cost upgrade and replacement of computer hardware and software resources. This business cost, although recognized, typically has not been considered in our department budget as an operations cost. In the past, funding for most improvements in computing capability were provided from headquarters activities, and no real identification of the year-to-year replacement costs was made. However, the department recently identified the cost of maintaining the computing capability. This cost was converted into an hourly rate based on the total number of available hours by direct performing individuals and included in the non-labor rate.

OTHER FEATURES OF DEVELOPMENT

Ease of Use

Ease of use of the model by its users was a necessary feature in our decentralized organization. No resources were available to input data on a full-time basis, so the task of providing cost estimates to customers and the Contracts Department had to be integrated into existing functions. Taken as a whole, the computing skills of our personnel were at the most basic level. Effective implementation depended on enabling persons with procurement knowledge to enter the "procurement-based knowledge" in a manner requiring little computing expertise. At the suggestion of High Performance Systems, Inc.—manufacturers of the I Think software used for UCM application—a "control panel" (Fig. 1) for data entry was created. The "buttons" displayed on the panel are the sources of data input for use in the I Think model. Entry of the values provided the entry for each occurrence of the particular cost entry, no matter what process was to be evaluated. The control panel provides an explanation of the function of each value, which identifies procurement features indicating additional process complexity.

Ease of Variation in Model Scenarios

Another important feature of the UCM is that inputs can be changed easily to show customers differences in costs based on varying levels of customer service, different types of direct labor, or other complexity factors affecting price. The model enhances a customer's understanding of the factors affecting cost and PALT with a graphical depiction of inputs and outputs.

REACTION IN THE FINANCIAL COMMUNITY

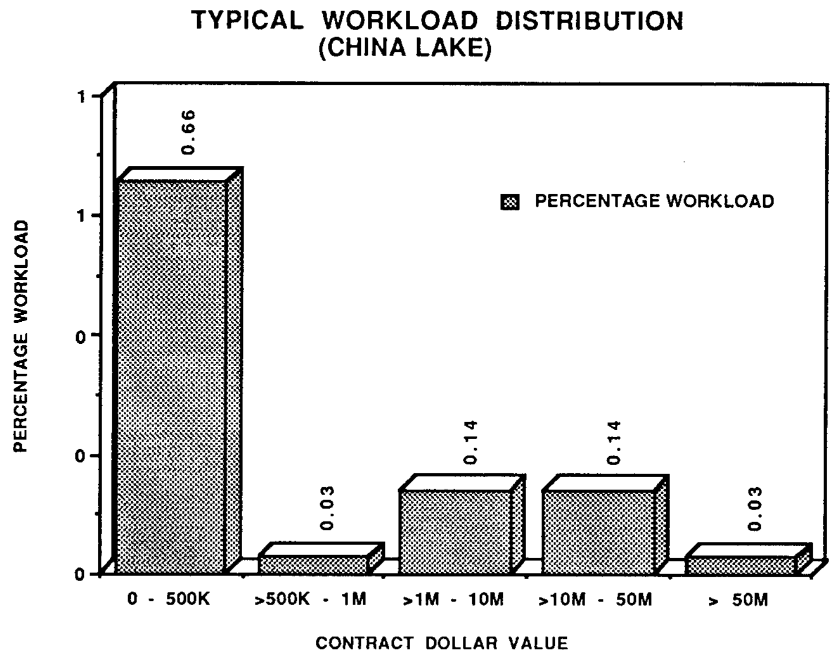
Some in the financial community have maintained that use of a "flat tax" would be much simpler to administer than this complicated model with so many factors influencing cost. Evaluation of a flat tax, where each customer is charged based on a flat percentage of the estimate of the value of the procurement, shows that the customer with the small procurement is vastly undercharged the cost of executing his procurement action, while the customer with large procurements is overcharged and indeed ends up subsidizing the small dollar procurements. Another problem with a flat tax is that quite often excess revenues must be returned at the end of the year, because the tax has generated a windfall of revenue from customers with multimillion-dollar requirements. Programs suddenly finding themselves with extra funds at the end of the year must quickly find vehicles to obligate the funding. The UCM approach of charging the customer based on the actual value received promotes effective consolidation of requirements, greater use of indefinite delivery indefinite quantity (IDIQ) contracts, and can use the procurement and technical customer labor more efficiently than will the award of many separate small dollar contracts.

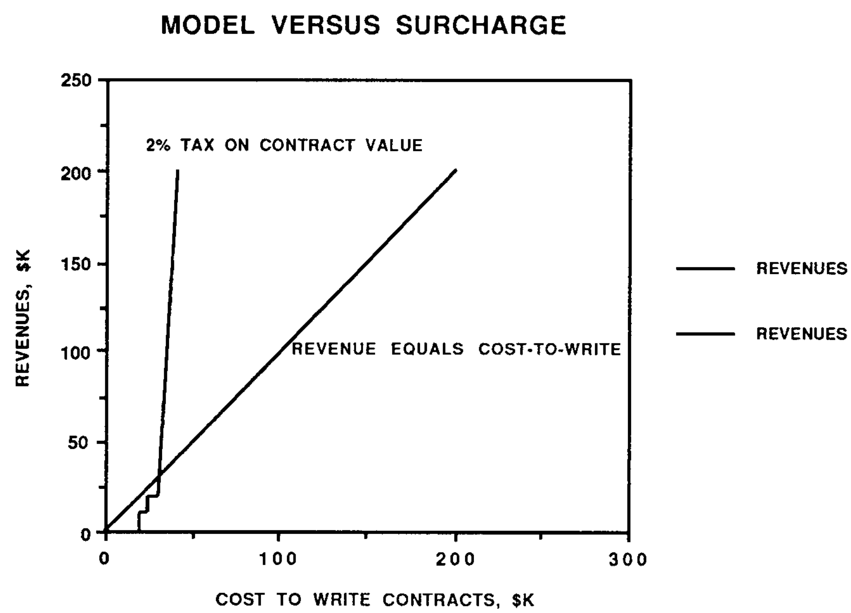
A flat tax misrepresents to customers the true cost to process requirements and, therefore, does not meet this key objective of the DBOF initiative. There is little chance that a large program office will want to find another activity to procure its requirement because the administrative cost of the procurement will be appropriately valued.

These arguments convinced NAWCWPNS management that we should proceed with the development and implementation of the UCM versus a flat tax on each customer. However, paradigms within the Comptroller's organization, based on poor experience with service centers, have to date made it impossible to implement a fee-for-service program based on the costs as identified by the UCM. The Comptroller has been unwilling to risk moving from G&A funding to the fee-for-service concept, based on the difficulty in forecasting workload and the lack of validation for the model assumptions. While the Contracts Department has not kept complete records of output or accurately forecasted workload in the past, we feel that implementation will focus personnel on more effective performance, bring in additional revenue for the Center, and provide the necessary incentive and focus to measure output and service performance. Inclusion of

a factor to compensate for time allocated by direct personnel to activities that do not generate revenue also will provide somewhat of a buffer to changing workload conditions.

For now the Procurement Department management has opted to implement the UCM internally, believing the improvement in measurement and accountability of our staff is a sufficient enough benefit to support the extra work imposed on the employees. Through internal implementation and improved methods of measurement, we intend to provide the Comptroller with the information necessary to support future implementation of a fee-for-service vehicle to support Procurement Department operations. The two graphs show a typical workload and a comparison of fee for service versus flat tax, respectively.





SELLING THE CONCEPT INTERNALLY

The major challenge for implementation has been in communicating the need for change and the responsibility of each person in the organization to do so. The project had the support of top management from the beginning. For the line managers, it was a different story. These managers were the most familiar with the problems of too few resources trying to manage too many changes in regulations and too many customer demands and deadline pressures. The last complication the management team wanted to deal with was additional reporting requirements imposed on their personnel. Implementation from top management down was the only feasible approach for a relatively quick implementation.

Internal briefings and demonstrations of the model were held for the management team and small groups of employees to introduce the UCM concept and explain what implementation would mean to our way of operating. At the briefings the employees were able to air their fears and concerns, such as implied performance standards and risks associated with charging customers per service rather than working under G&A funding.

During the internal briefings employees also were trained on the use of validation forms (Fig. 2) for completion and submission to the project office following execution of a procurement service. The forms were designed to collect the complexity information not collected in any of the manual or automated systems until implementation of the UCM. The validation forms were replaced at China Lake in November 1994 by implementation of Milestone Events used in the Automated Procurement and Accounting Data Entry (APADE) system. The Milestone Events are used by contract specialists to indicate status of a procurement requirement and the complexity of the requirement. Implementation of APADE milestones has improved our internal management information system and is providing critical information for management of workload.

The primary impetus for development of the UCM—the DBOF initiative—has not yet been implemented universally across DOD. Implementation at NAWCWPNS currently exists at only a top level within the Corporate Budget office, not greatly impacting day-to-day operations. However, if we are asked to fund our service operations through generation of operating funds, we will be ready. In the meantime, we have implemented use of the UCM internally, and are beginning to gather widespread performance data that will assist in the validation of the assumptions made in concept development. We also are using the cost information to communicate with our customers, so they will not be surprised when implementation occurs outside the department. Collection and analysis of our performance and operations data are beginning to meet our need to focus attention on the way we process our work and how to improve our processes.

CHANGE INFLUENCED BY THE UCM

Implementation of the UCM has influenced other process improvement/quality efforts in the NAWCWPNS Contracts Department. Since development and implementation, the need for measurement of quality and output throughout all levels of the organization has had a greater recognition. An improved understanding has been gained for the need for a comprehensive staff that can support such a project. The way the department staff is organized, no one office could have developed the UCM. Issues with the UCM's use and data elements touch on areas of administration, policy, or automation. As a result of changes both within and outside DOD, a greater realization has occurred that our staff functions can no longer afford to operate in separate spheres of influence, and changes in organizational structure are being made to ensure that improved teaming will occur on future projects. Implementation of the UCM has provided a focus on implementing other procurement management efforts. Information identifying the complexity of work-in-process must be available to measure the amount of work accomplished by the department. Implementation of an

improved information system was accomplished in part because of the need for the information by the UCM.

SUMMARY

Development and internal implementation of the UCM has provided a number of benefits to the Contracts Department at NAWCWPNS. The most obvious benefit is that we are prepared for implementation of the DBOF initiative, with respect to generation of operating revenue, with a well-thought-out model that effectively reflects our costs. The effectiveness of implementation of DBOF or some other fee-for-service initiative will not be degraded by a hastily created mechanism for generating revenue. Also, the model provides some much needed performance standards for the department. As we continue to refine our cost metrics, we will improve our management of scarce resources required to provide a particular service. Full implementation beyond our department will provide our customers with cost and schedule information to effectively plan and budget for acquisition requirements. Agreement of appropriate levels of customer service between Contracts Department personnel and technical customers will spell out the expectations for performance and revenue for both parties. Finally, the UCM provides management information essential for effective department operations.

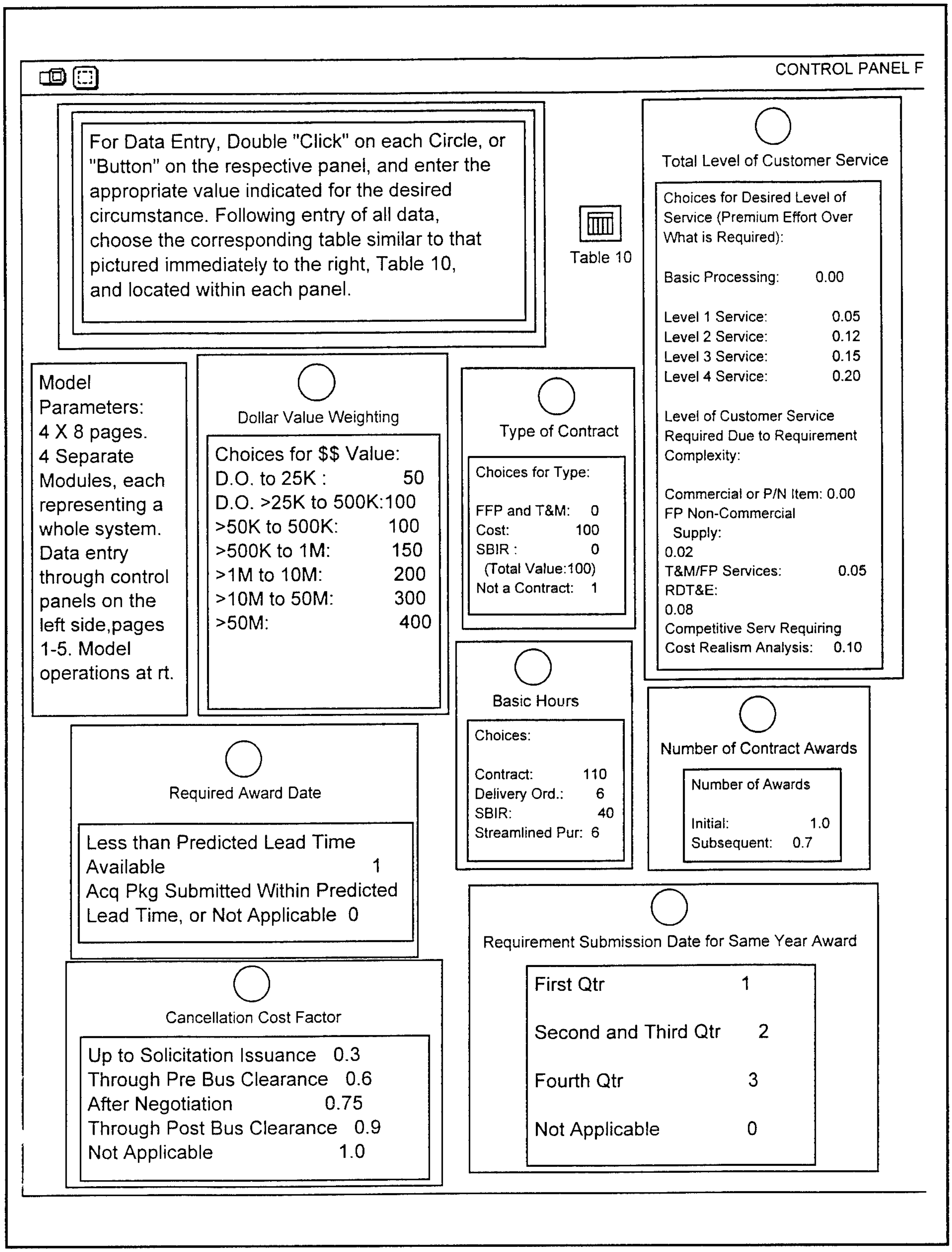
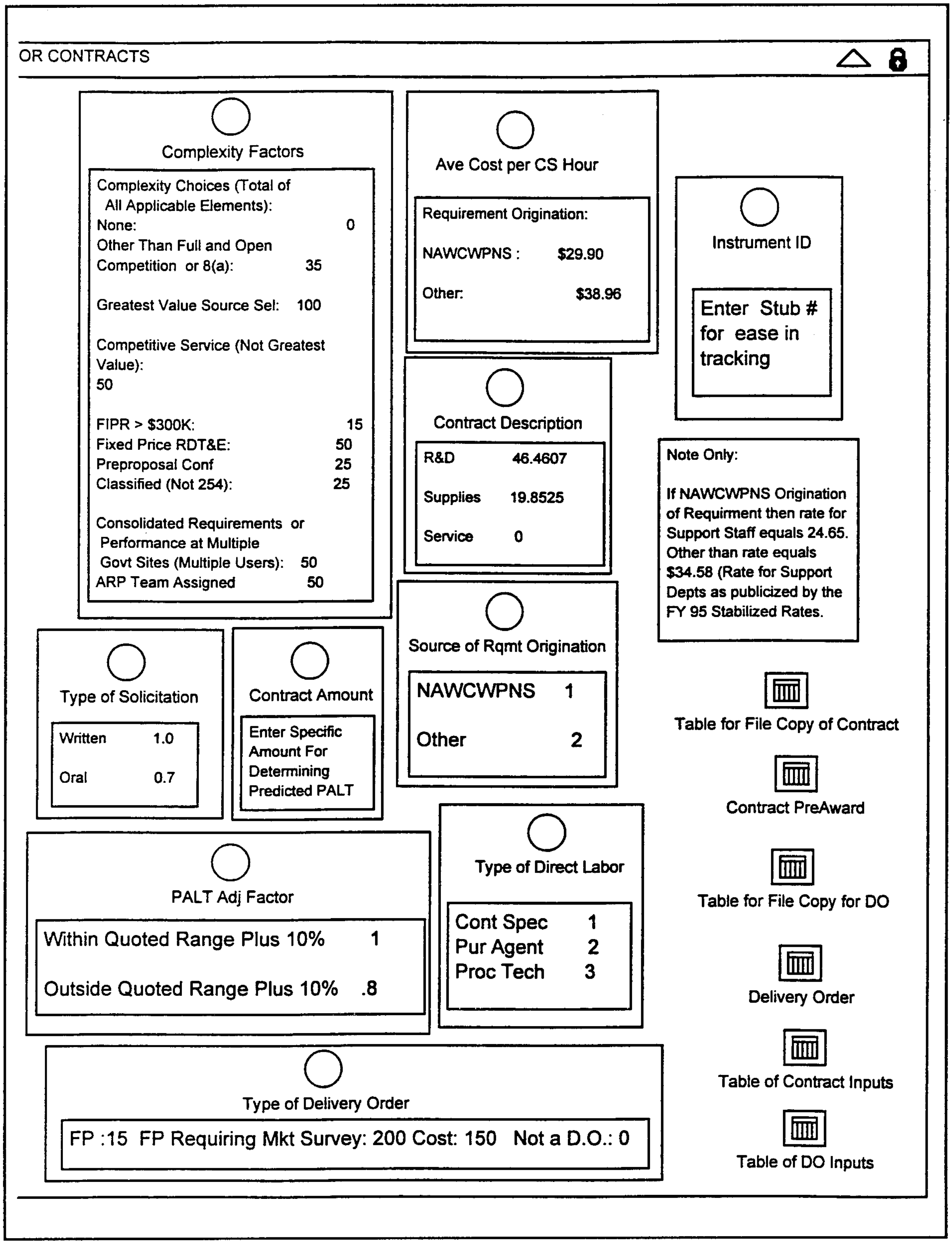


Fig. 1. Control Panel Data Entry.



OR CONTRACTS
Complexity Factors
Complexity Choices (Total of All Applicable Elements):
None: 0
Other Than Full and Open Competition or 8(a): 35
Greatest Value Source Sel: 100
Competitive Service (Not Greatest Value): 50
FIPR > $300K: 15
Fixed Price RDT&E: 50
Preproposal Conf 25
Classified (Not 254): 25
Consolidated Requirements or Performance at Multiple Govt Sites (Multiple Users): 50
ARP Team Assigned 50
Ave Cost per CS Hour
Requirement Origination:
NAWCWPNS : $29.90
Other: $38.96
Instrument ID
Enter Stub # for ease in tracking
Contract Description
R&D 46.4607
Supplies 19.8525
Service 0
Note Only:
If NAWCWPNS Origination of Requirment then rate for Support Staff equals 24.65. Other than rate equals $34.58 (Rate for Support Depts as publicized by the FY 95 Stabilized Rates.
Type of Solicitation
Written 1.0
Oral 0.7
Contract Amount
Enter Specific Amount For Determining Predicted PALT
Source of Rqmt Origination
NAWCWPNS 1
Other 2
Table for File Copy of Contract
Contract PreAward
PALT Adj Factor
Within Quoted Range Plus 10% 1
Outside Quoted Range Plus 10% .8
Type of Direct Labor
Cont Spec 1
Pur Agent 2
Proc Tech 3
Table for File Copy for DO
Delivery Order
Table of Contract Inputs
Type of Delivery Order
FP :15 FP Requiring Mkt Survey: 200 Cost: 150 Not a D.O.: 0
Table of DO Inputs

Fig. 1. (Contd.)

VALIDATION OF CONTRACT MODULE OF THE UNIT COST MODEL

An effort is being made to test the Unit Cost Model that predicts the cost to issue a contract, purchase order, etc. If you provide the following information, you will assist in validating the model.

SOLICITATION NUMBER	CONTRACT SPECIALIST		TECHNICAL CODE
ESTIMATED DOLLAR VALUE	CONTRACT TYPE	REQUIRED AWARD DATE	DATE ACCEPTED BY PROCUREMENT

COMPLEXITY ELEMENTS FOR THIS REQUIREMENT *(Check all that apply)*

(X)	ELEMENTS
	EXCLUSION OF SOURCES (J & A USED)
	PREPROPOSAL CONFERENCE
	GREATEST VALUE SOURCE SELECTION
	ORAL SOLICITATION
	SBIR
	SPLIT OR BAA AWARD ☐ INITIAL ☐ SUBSEQUENT
	SERVICE REQUIREMENT
	CLASSIFIED ATTACHMENTS *(Not DD 254)*
	FIPR REQUIRING LIFE CYCLE COST EVALUATION OR DESIRABLE FEATURES
	PREAWARD SURVEY REQUESTED
	FIXED PRICE RDT&E REQUIREMENT
	REQUIREMENTS FOR MULTIPLE SITES
	ARP TEAM ASSIGNED

TO BE COMPLETED BY
CONTRACT SPECIALIST *(Estimate number of hours required for processing)*

PROCESSING	HOURS
ACTUAL DIRECT CS HOURS TO PROCESS *(Up to and including award)*	
ACTUAL CUSTOMER SERVICE HOURS PROVIDED FOR THIS REQUIREMENT *(Include milestone meetings, other meetings, research hours, etc.) (Purpose of effort is to provide additional service to customer.)* ABOVE WHAT IS REQUIRED TO PROCESS THE REQUIREMENT.	
LEVEL OF SERVICE QUOTED CUSTOMER	
ACTUAL PROCUREMENT ADMINISTRATIVE LEAD TIME (DAYS)	

Problems encountered in the award of this requirement that are not captured by the above complexity elements:

NAWCWPNS 4330/(T1) (2-95)

Return your completed form and any other comments to Unit Cost Model Program Manager, 2T0000D (C6505). Your support and assistance is appreciated.

Fig. 2. Validation Form.

STUDY TO DETERMINE THE LIFE-CYCLE COSTS OF PURCHASE METHODS

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ABSTRACT

The China Lake, California, site of the Naval Air Warfare Center Weapons Division (NAWCWPNS) is chartered to support the research, development, test, and evaluation (RDT&E) requirements of Navy weapon systems. A key component of any effective RDT&E organization is the ability to move rapidly from concept to development to deployment. Any lead time that can be reduced before deployment in the field improves force readiness, and any savings accrued in administrative costs allow increased funds to be designated for technical support.

In an effort to improve procurement support to the technical customer, the management at NAWCWPNS China Lake supported the development and implementation of two innovative procurement methods, the Small Purchase Electronic Data Interchange (SPEDI) and Bankcard. The SPEDI program is based on requirements-type contracts using the Just-in-Time warehousing and delivery concept. SPEDI orders are placed via personal computer and feature on-line catalogs and search capability. SPEDI orders are restricted to requirements that do not exceed the small purchase threshold. The Bankcard program uses a commercial credit card to enable customers to procure requirements that do not exceed $2500.

These innovative small procurement methods, in addition to the traditional Simplified Purchase and supply system requisitioning methods, are in use at China Lake. However, as resources became more limited, a study to assess the cost-effectiveness of each method became imperative. The objectives of the study were to provide management with a better understanding of the costs associated with each method to promote the maximized use of the least costly methods, when appropriate, and to enhance effective allocation of department resources.

This study was concerned primarily with the effectiveness of each procurement method as measured only by the life-cycle cost to process requirements. That is, the cost of all procurement processing costs, plus the cost associated with processing the requirement external to the Contracts Department. A life-cycle concept was chosen to show true representation of cost rather than indicating costs incurred by the Contracts Department alone. This concept also served to eliminate a skewed measurement of effectiveness. The results of the final study, which indicated the cost to process each requirement line item, are as follow:

Bankcard	$26.39
Simplified purchase	$174.60
SPEDI	$97.18
Supply system*	$270.38.

* Includes the cost of warehouse operations and procurement.

Realizing that a purchasing method with an array of complex procurement issues cannot be addressed by cost-effectiveness alone, we addressed the goals of each method and its target markets. At the core of the study was the premise that each purchasing method was a valid concept developed to address particular needs of the customer and the procurement community.

This paper summarizes the methodology used by the study team, the study results, and how the study is being used at NAWCWPNS.

INTRODUCTION

In reviewing the effectiveness of processes, most organizations look only within their internal boundaries for definition of the process. This limited view of the scope of a

process ignores pertinent costs and other measures of effectiveness. The procurement process within the Federal Government is influenced by a number of factors external to the procuring organization. Factors outside the individual procuring organization that can and will affect the amount of lead time required to procure a requirement include adequacy of requirement definition, market forces, and changes in the regulations or their enforcement.

To assess how the Contracts Department at NAWCWPNS should allocate resources in support of systems to effect acquisition of needed supplies, we decided to perform a study of the cost of each method used by the department and its customers. Thus, the initial study to determine the life-cycle costs to process a small purchase, SPEDI, or Bankcard order was chartered.

The advantages of performing a study unencumbered by organizational boundaries are that the entire process can be compared side-by-side for similarities and differences. A resulting difference in cost can prompt a manager to question the differences between methods used by the same office and whether the differences are appropriate.

METHODOLOGY

A procurement analyst was teamed with a management analyst to interview the procurement process owners, as well as participants in other departments, including technical personnel as requirement originators; Bankcard holders; cost accounting/ comptroller; and plant account and supply personnel.

The initial assignment seemed rather straightforward, but the team soon realized that a study of costs in a process often brings out feelings and emotions rather than facts and data. The two innovative procurement methods, Bankcard and SPEDI, both having dedicated personnel believing in the "rightness" of their programs, were often competing with each other for customers in the same market. A great deal of emotion had to be sorted through to determine the best possible estimate of costs, given all the available information.

We began the study in February 1992. Our goal was to determine processing costs for Fiscal Year (FY) 1991 for the three procurement methods. Almost immediately we realized that FY 91 was not an ideal year on which to base future decision-making. Each method had unique situations that would distort costs. Bankcard was in its first year of transition from a manual process to an automated process. Even though particular attention was given to the needs of the Accounting Branch, a significant number of rejects caused backlogs of rework for accounting personnel. This rework caused accounting costs to soar while accounting technicians and technical Bankcard users were learning the process. SPEDI was still in early development, having had its initial contract awarded and in place for only 9 months. Contracts personnel in the SPEDI Division were still developing internal processes and methodologies for solicitation and award for various types of commodities. A significant portion of the man-years dedicated to this program were used to perform this research and development effort. The small purchase method, along with the newly automated Bankcard method, had to bear all the costs for operation and maintenance of the Tandem computer, even though major contracts would soon be automated and would share in allocation of this cost element.

For each method, it was natural to believe that FY 91 represented a transitional year and that any study proposing to serve the information needs of the department would need to forecast beyond that time. From an early briefing, management approval was obtained to conduct the study of FY 91 and the forecast for FY 92 and FY 93.

Where possible, process-specific costs were identified. Often personnel and resources are assigned to a variety of processes, so their costs are shared on a pro-rata basis.

GATHERING THE DATA

A sample of Bankcard holders and approving officials with varying levels of experience were interviewed to determine the average time spent processing credit card purchases, reconciling statements at the end of each month, and approving purchases. Small purchase buyers spent 100% of their available time processing small purchases, unless other work assignments significantly affected their availability to process small purchase requirements. For example, some of the purchasing agents also served as Bankcard representatives to their technical customers.

Approximately 30% of the average Bankcard representative's time was spent assisting customers, fielding questions on the application of regulations, and performing monthly audits of purchases. Thus, this time would be considered a cost to the Bankcard method rather than to the small purchase method.

In the initial interview, participants often did not know how much time was required for processing. Persistence in this line of questioning (sometimes offering suggestions, comparisons, and finally additional questioning) obtained an estimate of the participant's "gut feel." Without this follow-up from the team, some individuals would have just given up because they were not able to quantify their costs on their own. One probable explanation for this situation is that personnel in the Contracts Department are trained to work with great detail and precision regarding contract and Simplified Purchase costs. Such training does not easily lend itself to making an estimate of cost to be used for decision-making, especially when no management information is in place to capture supporting data.

Management personnel were queried to assess the amount of time spent in support of each method. This time varied from 10 to 100%, so each individual's estimated time was addressed separately. Actual labor costs were used when available. Otherwise, projected labor expenses were used.

Contractor support services, primarily in the areas of data processing and computer operations, were estimated to be continued at the same level for all years, except where changes in processes had eliminated the need for some types of support. The costs for these services were obtained from the technical monitor for the appropriate delivery order providing the service.

After assimilating all the data, the team often had to evaluate the individual responses and the given circumstances of each. In case of conflicting data, some responses were given more weighting than others based on the probability of that occurrence representing the normal experience.

EXAMINATION OF THE DATA

The team had multiple meetings and/or telephone contacts with personnel involved in using each method to obtain clarification or additional data regarding processes and costs. These contacts also served as a check and balance for the study, as the representatives tended to scrutinize time and other cost assessments for the other methods as well as their own. The team deliberately used the dynamics created by the examination of costs to break through early assumptions and to get closer to the representative costs.

Examination of the data by the interested parties also served to educate them to the costs allocated to specific areas of the process. Sometimes, the information provided was the exact opposite of the paradigm a person held. For instance, it was believed that Bankcard automation would improve the cost-effectiveness of the plant account process. In fact, Bankcard automation dramatically improved the efficiency with which plant account items were identified. However, due to improved identification measures, the number of acquisitions requiring plant account screening had increased enough to require additional labor to perform the function. Savings were expected at the next major triennial inventory due to fewer losses of plant property, but the exact savings could not be quantified at the time of the study.

FORECASTING CUSTOMER DEMAND

When we began our initial study of Simplified Purchase methods, FY 91 represented the only year to be studied that had complete data. To calculate costs for FY 92 and FY 93, we had to forecast the likely incoming workload for each method. Using the same level of workload for each year would have been easier, but we believed it appropriate to adjust the level of workload based on trends we had seen taking place. Traditional Simplified Purchase workload was steadily eroding, while Bankcard was being used more frequently each year. The SPEDI Division was actively reviewing both Simplified Purchase and Bankcard reports for demand data, indicating likely candidates for inclusion in an upcoming SPEDI contract. Because the customer base for each method was in a dynamic state of change, showing the effects of expected trends on the life-cycle cost to process requirements by forecasting the customer demand seemed the most appropriate way to arrive at realistic costs.

Forecasting proved to be one of the most challenging demands of the study. The major factors considered were as follows:

1. Specific SPEDI contracts anticipated to be available for use by the customer, anticipated customer volume, and percent of the fiscal year available for use after contract award and start-up lead time.

2. Effect of decreasing Department of Defense and NAWCWPNS budgets on demand for all methods.

3. Effect of increased numbers of SPEDI requirements-type (mandatory use) contracts on demand for small purchase and Bankcard business bases.

4. Number of personnel expected to be employed at NAWCWPNS, which would have a significant impact on the office supply contract for SPEDI, the source of a significant number of orders.

LIFE-CYCLE COSTS OF PROCESSING REQUIREMENTS

The following table provides our estimate for FY 91 life-cycle costs to process a requirement by each method on a per line item and per order basis. The costs indicated are not a judgment indicating what each method should cost, but merely our best assessment of the actual average cost to process a requirement by each method, as experienced by the Contracts Department and other departments at NAWCWPNS China Lake.

Method	No. of line items	L/I cost, $	No. of orders	Order cost, $
Bankcard*	51,841	30.98	23,564	68.15
Simplified purchase	25,134	178.35	9,309	481.57
SPEDI	11,243	86.45	11,243	86.45

*The cost of the Bankcard method is based on manual processing of documentation and end-of-month reconciliation of the bank statement of purchases. The automated method of processing documentation, with the benefit of automated funds approval before execution of the transaction, became operational during FY 92.

Fixed and Variable Costs

Fixed and variable costs provide information regarding which processes can be expected to see a reduction in costs due to increases in volume. Because the fixed costs associated with a process tend to remain stable with each increase in individual orders or line items processed, the fixed cost per unit decline. Variable costs tend to vary with each increase or decrease in units. Thus, on a unit price basis, the fixed costs will vary with the number of units while the variable costs will remain constant no matter what the order volume may be.

In a perfect world, labor could be shifted easily to other tasks when not being used. In practice we found that most of our costs are

probably semi-variable and semi-fixed. In the operation of government activities, personnel represent a fixed cost. Since NAWCWPNS, in effect, will experience this labor cost no matter what the level of work in process in Simplified Purchase, at least in the short term, we assigned Simplified Purchase labor to the fixed cost. Why an argument could be made to consider these costs as variable can easily be understood.

Other fixed costs for Simplified Purchase are computer support for operation of automated systems for accounting and procurement, analyst support of the Simplified Purchase function, Simplified Purchase management support, operation and maintenance of automated systems, and plant account. Variable costs include the cost for the customer to prepare the documentation for the requisition, obtain necessary approvals, receiving and delivery, and accounting.

Bankcard and SPEDI costs were addressed in a similar manner. Both these methods include operating costs unique to their method. A variable cost for Bankcard was the bank surcharge fee, the rate of which varied at the individual order level at any given time based on the total number of orders placed at the time processed by the bank. No other process experienced a bank surcharge fee as a cost of the process. Computer access charges are included in the SPEDI variable costs as they can be attributed to each individual order. No other method incurred such access charges from NAWCWPNS operations.

The following table provides a breakout of fixed and variable costs per line item for each method.

Method	Fixed cost, $	% of cost	Variable cost, $	% of cost
Bankcard*	6.03	20	24.95	80
Simplified purchase	100.51	56	77.84	44
SPEDI	60.19	70	26.26	30

Costs per line item and per order for fiscal years 1992 and 1993 were estimated to be as follows:

Method	1992		1993	
	Line item, $	Order, $	Line item, $	Order, $
Bankcard (Automated)	33.63	73.99	36.40	80.07
Simplified purchase	179.54	484.76	163.70	441.98
SPEDI	95.24	95.24	90.46	90.46

NOTE: The ratio of average line items per order is as follows: SPEDI, 1:1; Bankcard, 2.2:1; and Simplified Purchase, 2.7:1. The ratios were calculated for FY 91. Historically, these ratios have remained remarkably consistent over the last several years, and were used in our calculations whenever actual data were not available.

MEASURES OF EFFECTIVENESS OTHER THAN COST

The cost of a process reflects only a portion of its effectiveness in federal acquisitions. Other factors for consideration are the ability of the method to meet customer needs; the level of risk to procurement authority at the activity imposed by the process; and the ability of the process to meet performance goals established at inception of the process. To effectively manage resources and meet the needs of customers, managers must be aware of these other considerations. Some requirements may need to trade cost efficiency for other considerations. However, we found that the majority of requirements processed at NAWCWPNS would meet the characteristics of the target markets for processing by cost-effective methods other than traditional Simplified Purchase.

Target Markets

In performing our life-cycle cost study, we never intended to try to eliminate any Simplified Purchase method at NAWCWPNS. We believed that each method served valid customer needs, and identification of the target market for each method verified this belief.

The SPEDI method was determined most appropriate to procurement of high-volume, commercial, off-the-shelf products. Because the customer has no direct interaction with the vendor, the products available through the catalog must meet the customer requirement without the need for negotiation. Inclusion of high-demand requirements under SPEDI contracts promotes additional cost savings through negotiation of quantity discounts. The high percentage of fixed costs associated with process automation provides SPEDI with the potential for very low average-per-order costs if a high volume of orders is placed against its contracts.

The traditional Simplified Purchase method is most appropriate for acquisition of those requirements that may require negotiation of terms, conditions, or specifications for items not readily available for off-the-shelf purchase. The flexibility of this method, combined with a high dollar threshold compared to the Bankcard, enabled it to provide the highest return on operating costs of any of the three methods.

The Bankcard is effective for specialized, low-volume items that do not exceed the $2500 per purchase limitation. Bankcard also is effective for commercial, off-the-shelf items, but the method probably has already reached its optimum cost per order. Increasingly, the Contracts Department should include items with considerable customer demand in appropriate SPEDI contracts to reduce the average prices paid. The low per-line-item cost makes this method especially attractive over other methods for requirements within its low dollar threshold limitation.

Risk Assessments of Each Method

A further study objective was to assess the procurement risk associated with the improper use of each method studied. Procurement risk is defined as the probability that fraud, waste, abuse, or noncompliance of acquisition regulations or policies will occur at any given time within the processes of each method. We found that the SPEDI method presented NAWCWPNS with the least amount of risk. The low risk inherent with this method is due to negotiation of prices with volume discounts built into the basic contract, the on-line verification of availability of funding before placement of the order, and concentration of competitively awarded contracts for commodities in areas satisfied by commercial items. Furthermore, consolidation of customer needs into a requirements-type contract provides the Government with greater remedies than multiple purchase orders.

The built-in system of manual reviews and checks and balances present in processing Simplified Purchases provided a greater opportunity for human error than did the process for ordering via SPEDI. The number of reviews present in all areas of the process have a detrimental impact to administrative lead time, causing this method to experience the longest administrative lead time by far. Though this method has greater control by procurement personnel, the length of the processing cycle adversely impacts the customer by adding schedule and market risks.

The Bankcard method, like SPEDI, encourages quick processing of the requirement, delivery, and payment to the vendor. Automation of the process enables verification of funds to be made on-line while processing the order, saving time, and reducing the risk for each requirement. The primary risk associated with the Bankcard is that the cards are primarily in the control of and use by technical customers. Because these customers are not full-time procurement officials, delegation of procurement authority to these persons outside the Contracts Department carries a high level of risk of abuse of procurement laws and regulations. The relatively high level of risk associated with the Bankcard method is somewhat tempered by its limitation to purchases that do not exceed $2500, and again by total dollar limitations on a total monthly basis.

Performance Goals

Each method had a different set of performance goals its processes were designed to meet. SPEDI was designed to greatly improve the response time from initiation of

the acquisition requirement through the time of receipt of the item(s). Other SPEDI goals were the reduction of total procurement effort by consolidating recurring Simplified Purchase requirements and, thereby, reducing the procurement cost for small dollar purchases; achieving lower average pricing on requirements due to negotiation of volume discounts; improving quality of merchandise; providing easy accessibility to all personnel; lowering levels of government warehouse inventory; reducing inventory cost; and improving vendor payment times.

Goals for the Bankcard program were to improve response time from initiation of acquisition through receipt of the order; serve as a cost-effective alternative to the traditional Simplified Purchase method; empower technical users to obtain supplies directly for better mission support; and streamline payment to vendors.

The goal for the traditional Simplified Purchase method was to support the technical customer through the procurement of all requirements within the small purchase dollar limitation at fair and reasonable prices and in accordance with all applicable laws and regulations in effect.

Identification of the goals of each method is important to keep the role of each method in proper perspective, and the importance of objectives other than cost. All three purchase methods were determined effective in meeting their respective performance goals.

PRODUCT

The product of our study was a document that will serve managers of Simplified Purchase methods at NAWCWPNS for many years. This thorough documentation provides a basis from which future follow-up studies can be made easily. Critical to any life-cycle cost study are complete documentation of how costs were determined, the base of allocation, any unique circumstances influencing the costs, and the source of the information. From such documentation, discussions of the relevancy of cost estimates can be held. After a determination that most of the value-added effort in the proper identification of costs was achieved, the documentation properly serves as an historical record for future studies or comparisons.

A suggestion that discussions and reviews of a study might conclude after most value-added effort have been accomplished might seem odd to some. However, from experience I have found that in a search for the exact cost of a process, you might never finish the study! At some point a determination must be made that any remaining refinements of cost will be relatively minor and not affect the relative cost standings in question. A decision to conclude the study has to be reached.

PHASE II—THE SUPPLY DEPARTMENT STUDY

From the beginning of implementation of the SPEDI program, the Supply and Contracts Departments competed in the pursuit of a number of common items for processing through SPEDI and the Department of Defense Supply System. Disagreement about what items must legally be obtained from inventory through the supply system has had two major impacts to the SPEDI program. First, the SPEDI contracts are written as requirements contracts. Therefore, any requirement covered by a SPEDI contract that ends up also being procured through the supply system violates terms of the SPEDI contract, and ends up subjecting the command to claims from the injured contractor. Second, a restrictive interpretation of regulations that unduly limits the number of items available for purchase under SPEDI significantly impedes growth of the program.

With a relatively high percentage of fixed versus variable costs, SPEDI has the most potential of any of the methods to dramatically reduce its per order costs with an increase in order volume. This information is critical for management and customers alike, especially considering that the SPEDI contract providing the highest order volume is the contract for office supplies, representing an average of 73% of the total number of orders against vendor contracts in the last 3 years. As would be expected for a contract for office supplies, the average dollar

value for an individual order in those years was $91.86, making it vitally important to reduce the per order costs for these low dollar requirements.

Central to the argument of the Supply Department officials was the belief that their process was more efficient and less costly to the customer. After the initial life-cycle cost study was completed in January 1993, the Supply Department requested that a team work to study supply operations so that an understanding of the costs associated with the processing of orders would be available to all procurement officials. In June 1993, at the request of NAWCWPNS management, a team began the study of the supply processes and associated costs.

Counting Procurement Line Items Versus Issues

The single most critical issue the team faced was selecting the unit of measurement to be used as the basis for distribution of costs. Supply Department personnel proposed to use issues from their warehouse as the cost measurement unit. The Contracts Department representatives believed use of a line item as the basic unit of measure was the only valid approach because this unit was the only one common to all methods studied. A survey by the Supply Department determined that for FY 93 there was a ratio of 6.74 issues per procurement line item of material ordered. By the time the cost study team was chartered to analyze the real cost for processing supply requirements, the debate between the cost effectiveness of SPEDI versus issues from the supply warehouse had been ongoing for about 3 years. Both groups were so convinced of their own cost-effectiveness that they failed to see they were not using equivalent units of measure. This discovery, and getting our supply officials to acknowledge the difference, was a significant accomplishment of the study. The bases of allocation did not impact the total cost, merely the perception of how expensive a process was. The issue for the Supply Department was whether costs would be spread over 18,777 line items or across 90,384 issues. For the average person, $40.12 per issue sounds much more cost-effective than $270.38 per line item, although both figures represent the same actual cost.

Allocation of Elements of Cost Among Methods

Allocation of costs for the various methods was based on the percentage of the total number of line items processed using that method in the particular cost area. Some costs were determined to benefit more than one method equally, so these costs were shared equally. The primary example is in the area of computer operations support. Following the equal allocation per method, the amount was divided by the total number of line items awarded under each method.

COST OF SUPPLY AND OTHER PROCUREMENT METHODS

After 20 months of discussing costs for supply issues and system requisition orders, team members reached no agreement. Aside from whether costs should be identified per issue or line item, the primary remaining area of disagreement lay in the area of contractor operations in support of the Supply Department functions. Support for calculation of costs for elements in this area was never provided by other team members, so this study was never able to identify exactly the source of differences. Virtually all the supply data had to be gathered manually for this study. For most of the duration of the study effort, how many issues had been made, how many line items of requisitions had been processed, etc., was never really clear. This lack of available information prolonged the study beyond what we had anticipated.

Based on the exhaustive reviews and discussions held, the following costs for FY 93 represent what we believe to be the life-cycle processing costs for each method. The costs for some methods have been revised based on new information discovered during the second study.

Method	No. of line items	L/I cost, $	No. of orders	Order cost, $
Bankcard	61,978	26.39	26,536	61.65
Simplified purchase	19,578	174.60	7,543	453.17
SPEDI	17,086	97.18	17,086	97.18
Supply* operations	18,777	270.38*	N/A	N/A
Supply issues	90,384*	40.12*		

*No figure was available for Supply Department orders. The number of issues represents the total number made at the warehouse. Cost per line item includes cost for MILSTRIP orders for individual use and for stock, and warehouse costs of locally stocked items.

Method	Fixed cost, $	Fixed % of cost	Variable cost, $	Variable % of cost
Bankcard	2.71	10	23.68	90
Simplified purchase	97.78	56	76.82	44
SPEDI	68.03	70	29.15	30
Supply	51.44	19	218.94	81

Bankcard has achieved a low fixed-cost per line item based on its large volume of orders. Because such a small percentage of the total cost is associated with fixed costs, the Bankcard process will find it difficult to greatly reduce its cost when the total cost is already very low. The automation associated with Simplified Purchase and SPEDI, as well as a relatively fixed workforce, provides the fixed costs for these methods. SPEDI is particularly well positioned to lower its costs due to a high percentage of fixed costs. The high variable costs associated with the supply processes reflect an absence of effective automation. Though most of the processes in FY 93 were manual, the existing automation was determined ineffective and required considerable manual intervention for processing of requirements. Implementation of automation after FY 93 was expected to improve processing efficiency and costs after the initial start-up period. Future studies will be made to capture the expected cost reductions.

CONCLUSION

The benefits of performing a life-cycle cost analysis lie in understanding the nature of costs of an operation, identifying an organization's leverage points, and developing an improved capability for strategic planning based on cost efficiencies and market advantages. The perspective we obtained from our studies was that an exact number can be elusive due to a number of estimates and assumptions that must be made. More important was the understanding that the relative standing of the various procurement methods remained constant, no matter how many times a particular cost element was revised. Allocation of costs over a base with many thousands of units requires significant cost changes to greatly affect the unit cost.

You may feel that quantifying some costs is just not possible; therefore, a life-cycle cost analysis is not possible. Every organization probably has some of these costs not previously recognized. Through the use of documented logical assumptions, previously unquantified costs can be attributed to a service or a product. You may not feel comfortable using assumptions to develop costs that will form the basis of decision-making, but the organization will be better served through the attribution of these costs rather than simply ignoring them.

A METHODOLOGY FOR ESTIMATING BEST VALUE

Janine L. Faris
Joan S. Lovelace
The MITRE Corporation

ABSTRACT

The methodology described in this paper takes only a few steps beyond the Federal Information Processing (FIPS) guidelines. The term "Best Value", or "Greatest Value" has no statutory or regulatory definition. In general, the policy, processes, and procedures of awarding contracts on factors other than cost can be termed Best Value (or Greatest Value). More specifically, the Best Value concept requires the source selection authority to examine the strengths or advantages of each proposal to determine if the increased costs are of sufficient value to the Government to justify an award to other than the lowest responsive and responsible offer.

A METHODOLOGY FOR ESTIMATING BEST VALUE

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The goal of the United States Government's federal procurement process traditionally has been to acquire products that meet the minimum needs of the Government for the lowest price or lowest total cost to the Government. However, the Federal Acquisition Regulation (FAR) also recognizes that:

While the lowest price or lowest total cost to the Government is properly the deciding factor in many source selections, in some acquisitions, the Government may select the source whose proposal offers the ***greatest value*** (emphasis added) to the Government in terms of performance and other factors . . *FAR 15.605 (c)*

This is most often the case in negotiated procurements where the technical design or development approach may be important to the success of the development effort. It is also increasingly the case in service contracts where past performance on similar contracts is considered. At present, the term "Best Value", or "Greatest Value" has no statutory or regulatory definition. In general, the policy, processes, and procedures of awarding contracts on factors other than cost can be termed Best Value (or Greatest Value). More specifically, the Best Value concept requires the source selection authority to examine the strengths or advantages of each proposal to determine if the increased costs are of sufficient value to the Government to justify an award to other than the lowest responsive and responsible offer.

The policies and procedures pertaining to Best Value source selections are delineated in FAR Part 15 and the Federal Information Resources Management Regulation (FIRMR) Subpart 201-39.15. There is not a great deal of additional literature on Best Value Analysis. One source is the General Services Administration's (GSA) document on Best Value entitled Source Selection: Greatest Value Approach (Federal Information Processing (FIPS) Resources Document #KMP-92-5-P). Of course, this guidance applies only to Automated Data Processing (ADP) procurements under the GSA purview. The emphasis of this particular publication is on how to structure the solicitation, including how to develop the source selection plan and the evaluation factors. Although the document describes a four-step trade-off methodology for the cost/technical trade-off, as one possible methodology for the Best Value Analysis process, the guidance is brief and very high level. The document states that there is no "magic formula" in performing a cost/technical trade-off, and that whatever methodology is used must be well-documented with relevant facts and supporting rationale. It also notes that non-quantifiable factors should also be used in determining the greatest value to the Government.

In the absence of statute or regulation, the authority for how to conduct a Best Value analysis must be extracted from case law. Most case law stems from protests heard

before the General Services Board of Contract Appeals (GSBCA), the most significant of these being the Oakcreek Funding (1991) case, the Army's Reserve Component Automation System (RCAS) December 1991 case, and the two Treasury Multiuser Acquisition Contract (TMAC) decisions. The outcomes of these cases have called for a more rigorous analysis when award is being made to a technically superior offer with a significantly higher cost (i.e., not the lowest-priced proposal). This has been reinforced by General Accounting Office Comptroller General-adjudicated-cases where there was concern as to whether the technical superiority was worth the cost premium. In calling for a more rigorous analysis, the appeal boards have shown no preference for descriptive, adjectival, or point scoring evaluation systems. There has been no objection to the Government making a cost adjustment to the proposal to reflect cost realism (based on an assessment of cost risk), or projecting life cycle costs to the Government.

Although quantification to assess the impact of technical discriminators (e.g., mission effectiveness, productivity, training effectiveness) is accepted, the adjudicating bodies have also recognized that non-quantifiable factors are likewise important. Of some concern to the cost estimating and analysis community is the fact that acceptable methodologies for Best Value Analysis appear to be increasingly determined outside the community that traditionally performs value analysis. This paper is an attempt to inject our community into the debate on what constitutes an appropriate analysis for a Best Value contract award. Though this paper is written from the perspective of someone serving on a source selection team and responsible for performing the cost/technical trade-off; cost analysts who are involved in source selections, either from the proposal preparation perspective, or the source selection team perspective, can benefit from an examination of this issue.

Planning for Best Value

A Best Value approach to source selection requires additional preparation and notice to potential offerors about the evaluation methodology. This planning is necessary to ensure adequate competition and a level playing field and to mitigate the threat of a protest. The following considerations, some of which are discussed in detail below, are important for planning for Best Value evaluation and analysis.

- Plan in advance how the Best Value Analysis will be conducted. Since there is no generally-accepted method of performing a Best Value Analysis, a systematic methodology starting with the Acquisition Plan and coupled with detailed documentation of the process and logic utilized by the evaluation teams, will enhance the probability of avoiding a protest.

- Identify potential discriminators in advance and build the evaluation factors around them. Discriminators must be linked to an evaluation factor, even if indirectly. If a discriminator cannot be linked to an evaluation factor, it cannot be considered. Similarly, if one approach (e.g., distributed processing) is viewed as superior before the solicitation is released, it must be identified as a requirement rather than a discriminator.

- Anticipate how benefits will be measured and collect the baseline data needed for analysis. If, for example, improved productivity is one of the

anticipated benefits, you will need to know the current number of staff and the average output. If these data are not collected in advance, it will lengthen the time for the Best Value Analysis and may raise questions regarding the efficacy of the proposal evaluation process.

- Determine how you will perform the risk analysis and how the results will be factored into the overall evaluation. Again, if some technical risks can be anticipated, determine how to translate that risk into a cost.

At present, the courts have upheld the Government's application of a Best Value Analysis when both the approach and the results have been documented and reasonably support the decision of the Source Selection Authority. The approach described below offers a starting point for the development of a best value methodology.

AN APPROACH TO ESTIMATING BEST VALUE

In the absence of a generally-accepted way to perform a Best Value Analysis, this paper offers a particular methodology as one of the ways in which such an analysis can be performed. This methodology consists of the following four steps:

Step One: Cost Realism Analysis

Step Two: Quantification of Risk

Step Three: Assessment and Quantification of Value

Step Four: Cost/Technical Trade-Off

Critical to the process is the development of clear and cogent supporting documentation and rationale, which will be an integral part of the completed analysis. The Best Value Analysis will be a key element of the evidentiary documentation should there be a protest.

Step One: Cost Realism Analysis

The objective of the cost realism analysis is to calculate the realistic cost to the Government, excluding quantification of risk, which is addressed later in Step Two. The calculation of realistic costs normally includes both the cost of the acquisition as well as operations and maintenance (O&M) costs, or life cycle cost (LCC). The O&M cost may be outside the scope of the procurement, but is usually necessary to develop in order to accurately perform a Best Value Analysis. (A Best Value procurement for ADP under the GSA purview **requires** that O&M costs be evaluated.) The inclusion of at least some elements of LCC must be included in the evaluation criteria if the Best Value Analysis plans to look at improved productivity as projected cost savings from the new systems.

After examining each offeror's cost proposal for compliance with the proposal preparation instructions as delineated in Section L (Instructions to Offerors) of the solicitation, and the schedule as delineated in Section B of the solicitation; the analyst must carefully examine each offeror's Basis of Estimate for realism, adequate substantiation, and logic, including the following:

- Staffing profile

- Labor Rates

- Bill of Materials (If extensive, concentrate analysis on high value and numerous quantity items)

- Other Direct Costs (ODCs)

- Profit/Fee (Should be consistent with contract type, and not exceed statutory limits)

As part of this process the analyst should also examine the following:

- Compare the key cost elements and Basis of Estimate with industry standards and practices

- Compare the Basis of Estimate with past projects/programs

- Obtain technical evaluation team input on the realism of the proposed technical labor effort given the technical approach

- Examine estimates of O&M cost, if required with the proposal submittal

The above-described process results in the development of an Independent Cost Estimate of all or portions of each offeror's proposal. It is critical to note that any issues of cost realism must be discussed with the offerors, either through the Clarification Request/Deficiency Report process, or during actual discussions. The Independent Cost Estimate will generally be developed using a combination of estimating methodologies -- parametric, engineering, and analogy, and will include an estimate of O&M costs. Following the submittal of Best and Final Offers (BAFOs), the Independent Cost Estimate should be reassessed and, if necessary, adjusted.

The following table illustrates Step One of a Best Value Analysis in a hypothetical procurement:

Table 1.0. Step One of a Best Value Analysis - Development of the Independent Cost Estimate Cost in Million Dollars

Price	Offeror A	Offeror B	Offeror C	Offeror D
Proposed Price	$55.0	$59.5	$65.0	$50.0
Cost Realism Independent Estimate	5.0	4.5	1.5	14.2
Subtotal	$60.0	$64.0	$66.5	$64.2

Note: For illustrative purposes only; not derived from project data.

The Cost Realism Analysis addresses estimating errors, incomplete costs, and unrealistic costs (such as understaffing).

Step Two: Quantification of Risk

Concurrent with the cost proposal evaluation process, the technical team and the management team will evaluate the

respective technical and management proposals. Generally this evaluation is conducted independent of the cost proposal evaluations. Similar to the cost proposal evaluation, the technical and management evaluation teams do the following:

- examine each proposal in relation to the evaluation factors and significant subfactors (as reflected in the source selection plan and Section M of the solicitation)

- measure each proposal against the evaluation standards and assign a rating

- identify proposal ambiguities and inadequate proposal substantiation and have the Contracting Officer obtain clarifications and additional information

- identify and document the strengths, weaknesses, and risks of the competing proposals

- identifydeficiencies/unacceptable proposals

- if possible, arrive at a consensus of the team on the final rating of each technical proposal (if consensus is not possible, thoroughly document dissenting opinions)

- work with the cost evaluation team to establish the competitive range

- hold meaningful discussions/negotiations with all of the offerors in the competitive range

The identification and documentation of the strengths, weaknesses, and risks of each proposal lays the groundwork for the risk assessment and cost/technical trade-off steps of the Best Value Analysis, because it determines the significant areas of difference, or discriminators, among the proposals. Following BAFO submittal, the technical and management evaluation teams share the results of their evaluations with the cost team. At this point the combination of ratings are determined. If **all** proposals are determined to be technically equal, then award should be made to that offeror with the lowest cost proposal. If the proposal with the highest technical merit is also the lowest cost proposal, then award should be made to that offeror. However, the source selection is usually not that simple. For example, the lowest priced proposal may have unacceptable or high technical risk. Conversely, the highest technical proposal may have the highest price; however, further analysis may show that the highest price may be warranted by low risk and superior management. This paper assumes a scenario in which the technical proposals are not technically equal in merit. Table 2.0 is an illustrative representation of the initial results of all the team evaluations.

Table 2.0. Initial Reports from Technical, Management, and Cost Evaluation Teams Cost in Million Dollars

Price	Offeror A	Offeror B	Offeror C	Offeror D
Technical Team Rating	Fourth	Second	First	Third
Qualitative Risk Assessment	High	Medium	Superior	Acceptable
Management Team Rating	Acceptable	Superior	Superior	Acceptable
Proposed Price	$55.0	$59.5	$65.0	$50.0
Cost Team Realistic Cost	$60.0	$64.0	$66.5	$64.2

Note: For illustrative purposes only; not derived from project data.

In this portion of the analysis, the cost evaluation team must quantify the technical and management risks which have been identified during those respective evaluations. To accomplish this quantification, the cost evaluation team will work closely with the technical and management evaluation teams. This quantification effort translates the technology and business risks associated with each offeror's proposal into cost. Each quantifiable risk has a range of cost, with probabilities associated with each point estimate falling within this range. Typical high-risk areas include, but are not limited to, the following:

- Maturity of technology (state-of-the-art)
- Reliability, availability, maintainability requirements
  Levels and types of integration
- Rights to technical data
- Business management risks (e.g., performance on past programs)
- Schedule risks
- Multinational teams

Not all risks are quantifiable. These residual, qualitative risks (e.g., ease of use, dependency on key individuals, etc.) must also be addressed and included in the Best Value Analysis. The result of the risk assessment is the expansion of the point estimate into a range estimate with a corresponding probability distribution. A point estimate with an associated probability of completion at the estimated cost and schedule, which is acceptable to the agency, can then be selected. The selected probability is dependent upon contract type and how much risk the agency is willing to assume. For example, if the contract will be Cost Plus Fixed Fee, then the analyst may want to select a value for the estimate which has a higher probability of success, such as an 80% probability, than if the contract is one of the Fixed Price type of contracts. In the latter case a lower probability of success may be warranted, such as a 50% probability. The combination of the independent cost estimates and the risk as-

sessments results in a most probable cost to the Government. Table 3.0 illustrates the additive nature of the Best Value Analysis.

Table 3.0. Step Two - Quantification of Risk Cost in Million Dollars

Price	Offeror A	Offeror B	Offeror C	Offeror D
Proposed Price	$55.0	$59.5	$65.0	$50.0
Cost Realism Independent Estimate	5.0	4.5	1.5	14.2
Technical/Management Risk Quantification Range	5.0 - 6.3	1.5 - 2.75	.5 - 1.2	2.5 - 3.2
80% Probability of Success	6.0	2.5	1.0	3.0
Most Probable Cost to the Government	$66.0	$66.5	$67.5	$67.2

Note: For illustrative purposes only; not derived from project data.

At the completion of this step in the Best Value Analysis, the cost, schedule, technical, and management risks have been identified and quantified where possible.

Step Three: Assessment and Quantification of Value

The next step in the Best Value Analysis is for the cost analyst to assess and quantify value, to the maximum extent possible. This assessment is derived from the strengths and weaknesses which have been identified earlier in the evaluation process. These strengths and weaknesses are linked to the evaluation factors/significant subfactors, and have been defined in regard to each evaluation factor/significant subfactor's respective evaluation standard, ensuring a good audit trail and minimization of bias. Examples of potential value element include:

- additional costs for renewal of licenses
- a larger footprint for a particular offeror's system
- early delivery

- better management structure
- more experienced personnel
- greater adherence to open systems standards
- better software development practices
- superior user training package
- friendlier user interface
- corporate history of excellent performance

If weaknesses are perceived, then the value will be reduced. Those value elements which cannot be quantified are set aside and later factored into the evaluation process. Table 4.0 presents the results of a hypothetical quantification ofvalue.

Table 4.0. Step Three - Assessment and Quantification of Value Cost in Million Dollars

Price	Offeror A	Offeror B	Offeror C	Offeror D
Early Delivery	--	$2.5	--	1.5
Friendlier User Interface	--	3.0	--	--
Superior User Training	--	--	3.0	--
"Lights Out"	.5	2.5	3.0	2.0
Earlier Obsolescence	--	--	2.5	1.0
Value	$0.5	$8.0	$8.5	$4.5

Note: For illustrative purposes only; not derived from project data.

Step Four: Cost/Technical Trade-off

The next step in the Best Value Analysis is to perform the Cost/Technical Trade-off by examining the most probable cost in relation to the quantified values (which have been developed from the technical and management assessment of strengths and weaknesses). A net value for each proposal is developed by subtracting the marginal benefits from the most probable cost. The net value is a metric used to examine comparative adjusted cost given benefits, or "value" to the Government. Net value does not represent the estimated cost that the Government may pay "out-of-pocket" for this acquisition -- that value is represented by the Most Probable Cost. The proposals are then ranked given the results of the net value. Table 5.0 presents the net value result of the cost/technical trade-off.

Table 5.0. Net Value By Offeror
Cost in Million Dollars

Cost Element	Offeror A	Offeror B	Offeror C	Offeror D
Most Probable Cost	$66.0	$66.5	$67.5	$67.2
Value	.5	8.0	8.5	4.5
Net Value	$65.5	**$58.5**	$59.0	$62.7

Note: For Illustrative purposes only; not derived from project data

The results in Table 5.0 indicate that Offeror B is the best quantified value at this point in the analysis.

Table 6.0 presents a history of how the relative rankings have changed at each step in this Best Value Analysis, with cost rankings delineated as "First" being the lowest cost, and "Fourth" being the highest cost. Likewise, technical rankings are delineated as "First" being the highest technically-ranked proposal, and "Fourth" being the lowest technically-ranked proposal.

Table 6.0. Relative Rankings For Each Step of the Best Value Analysis
Cost in 1994 Million Dollars

Best Value Analysis Step	Offeror A	Offeror B	Offeror C	Offeror D
Proposed Price	Second $55.0	Third $59.5	Fourth $65.0	**First** **$50.0**
Cost Realism Independent Estimate	**First** **$60.0**	Second $64.0	Fourth $66.5	Third $64.2
Technical Team Rating	Fourth	Second	**First**	Third
Most Probable Cost	**First** **$66.0**	Second $66.5	Fourth $67.5	Third $67.2
Net Value	Fourth $65.0	**First** **$58.5**	Second $59.0	Third $62.7

Note: For Illustrated purposes only; not derived from project data

The recap of rankings in Table 6.0 illustrates how the value of each offeror's proposal, and the relative rankings, changed during the Best Value Analysis process. When the cost evaluation team calculates Net Value, all of the quantifiable costs, risks, and value have

been assessed and factored into the analysis. The results in Table 6.0 indicate that at this step in the Best Value Analysis, the second highest technically-ranked offeror, Offeror B, is the best quantified value. The last step in the Best Value Analysis is to consider the non-quantified risks and values of each offeror's proposal. Once the qualitative risks and values have been factored into the evaluation, then the Best Value to the Government can be determined, and a source selection decision can be made.

Bringing it all Together

The final step is to present to the Source Selection Advisory Council (or SSA) the results of the quantitative analysis and the qualitative assessment and, depending on the preferences of the SSA, a recommendation for award. Before the final ranking, the quantitative analysis should be reviewed closely. In particular, the range of probable costs associated with the risk assessment should be examined. Where the offerors' most probable cost ranges overlap, it might be advisable to perform a sensitivity analysis. The non-quantified or residual risks should be revisited to ascertain whether any were serious enough to influence the ranking; for example, an adjectival description of high, medium or low could be assigned to the residual risks. These could be translated into a percentage of additional cost.

In a similar fashion, the non-quantitative values must be assessed.

Throughout this approach, the attempt has been made to quantify what can be quantified objectively and to retain the non-quantifiable elements for the complete analysis. The ability to quantify a particular risk or a benefit is often a function of the time and data available. To the extent that improvements in productivity or operating costs can be anticipated, those persons responsible for delineating the evaluation process should also be responsible for collecting the data and establishing the baseline in advance of the evaluation; however, some offerors' benefits will not be foreseeable and in other cases the data may be too time-consuming or expensive to collect. Subjective estimates of value can never be completely eliminated from the process. Also, it is worth emphasizing here that even the most highly quantified analysis does not result in "an answer." The purpose of the Best Value Analysis is to support the decision-maker, not make the decision.

Issues

There are several issues associated with a Best Value Analysis that remain unresolved for the authors.

1. Should the analysis be conducted at the element rather than the aggregate level? There is an underlying assumption that the difference in cost between the most probable cost of two proposals can be attributable to some difference in either the product itself or the process of developing or providing the product. Most of the analyses performed to date, as in the example above, analyze both the costs and benefits at the aggregate level. This masks the relationship between the cost differential and the benefit for any individual element. At the element level, there is not necessarily a direct correlation between the increased value of an element and an increase in cost. In fact, at the element level, an increase in value for superior software development methodology may result in lower costs. If a portion of the proposal's higher overall costs cannot be

attributable to the value of an element, it is unclear how that case should be considered in the analysis.

2. Should the Best Value Analysis weight the benefits in accordance with the weights assigned to the evaluation factors in the Source Selection Plan? As noted above, all the offerors considered in the Best Value Analysis meet the Government's requirements. The Best Value Analysis, for the most part, deals with marginal value. Frequently the discriminators relate back to relatively low-weighted evaluation factors. However, where there is a difference in the factor weights, the relative importance has not been adequately addressed in the Best Value Analysis. To some extent the "value" estimated for each discriminator considers the importance of that feature, but only imperfectly. This issue has already been raised as part of the TMAC protest and although the Government's decision was sustained, it should not be considered settled.

In summary, the methodology described above takes only a few steps beyond the FIPS guidelines. It is imperative that the cost estimating and economic analysis community become involved in the development of Best Value methodologies -- it should not be left to lawyers and boards of contract appeals to determine.

IMPROVING USAF EFFICIENCY: IN SEARCH OF METRICS

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ABSTRACT

Assessment of performance is a key issue in the DOD. Commanders of all types of organizations are constantly searching for metrics to determine if their organizations are improving. We address ways of measuring improvement in this paper. This issue has become increasingly significant in light of the National Performance Review (NPR) (Gore, [9]). In this study, we examine three USAF policy alternatives: (1) privatization of USAF functions, (2) promotion of competition between USAF facilities and other government entities or civilian contractors, and (3) continuous improvement of USAF processes. We argue that these initiatives should support the goals of increasing efficiency while maintaining combat capability. To determine which policy initiative is appropriate, we suggest activity based costing (ABC) and financial analysis as means of measuring costs and assessing performance.

INTRODUCTION

The American defense budget has been shrinking in real terms since the mid 1980s. From 1985 through 1997, the DOD projects overall defense budget cuts to equal 42%, personnel cuts of 30%, overseas base closings of 35%, and US. base closings of 15% (DOD Comptroller, [4]). Despite these cuts, the requirements to support critical national interests in various regions of the world remain. With shrinking budgets and steadily growing requirements, DOD is focusing on initiatives to increase efficiency of operations. The Air Force, for example, is experimenting with a new composite wing model that consolidates operations and reduces the cost of administrative and command redundancies (McPeak, [15]). Despite these attempts, numerous factors such as the DOD's complex organizational structure, lack of incentives to improve operations, and ever shifting requirements and direction have hampered improvement efforts. Yet many within DOD believe that dramatically improved efficiencies are possible without decreases in combat capability.

These efficiencies can come from two sources. First, some DOD functions may be better performed by the private sector. Second, some DOD processes can be improved. Minimizing overall costs while maintaining combat capability is the goal. DOD policy has always been directed at getting the most goods and services for the least amount of money. However, finding new and innovative ways to reduce costs is particularly important during the current downsizing period.

While this goal of improved efficiency is important, there are impediments. They include a lack of political

will. Prager [18] argues that the public sector is inefficient because of "...a lack of political will to establish efficiency as a high-level priority of government operations" (p. 180). He goes on to say that policy makers de-emphasize efficiency as a goal by not providing management with the flexibility to pursue efficiency goals and because "...the incentive structure of the public sector either is neutral toward or even discourages cost savings" (p. 180). Kelman [13] suggests that the lack of competition, autonomous choice, profit motivation; and timely procurement source selection decisions undermine government efficiency. Values like an equitable distribution of government contracts for procured goods are sometimes competing goals as well. Lastly, Meier [16] argues that efficiency within many public organizations is not even a relevant goal, "The goal of government agencies is universal service rather than efficient service" (p.7).

Other goals and objectives at stake when addressing efficiency come from the defense industry, DOD employees, and Congress. Defense industry management has the goal of maximizing shareholder wealth. Wringing efficiencies out of DOD may come partly at contractor expense. DOD personnel want to maintain their jobs and advancement potential within their organizations. Congress also is a major policy actor that fears losing control if various streamlining initiatives are accomplished.

EFFICIENCY AND COMBAT CAPABILITY

The dilemma facing the USAF is that it must be both efficient and combat capable. A policy design must value both goals. Combat capability, training and equipment, and the mental state of the fighting force may conflict with policies that improve efficiencies. One example is deciding to buy a new weapon system rather than upgrading an older weapon system. The way to decrease costs may be to simply upgrade an older system, but this may not be appropriate depending on the enemy's threat level, state of technology and other factors.

Incentives may be useful to motivate individuals to perform with cost minimization in mind. As Arrow [1] suggests in principal-agent theory, the costs associated with an agent pursuing self-interested behavior must be minimized by instituting rewards that motivate behavior desirable to the principal. These rewards need not be strictly financial. Power, prestige and public service are other valid rewards (Prager, [18]). Ingram and Schneider [12] describe motivational tools useful for public sector decision managers. These tools include: authority, capacity building, symbolic and hortatory, and learning tools.

Deciding how to reward public sector employees is often a difficult task. In some areas where government agencies perform services similar to those offered by the private sector, comparisons of efficiency may be appropriate. For example in the USAF, health care, vehicle and aircraft maintenance, and security have similar counterparts in the private sector. Comparisons within these activities may shed light on how to reward employees and improve operations. But comparisons are difficult where the function has fewer private sector characteristics (such as combat operations).

Before developing specific policy alternatives, we define efficiency and combat capability. Two definitions of efficiency are:

"getting the greatest aggregate good from available resources" (Weimer and Vining, [22], p. 16) and "...the ratio between inputs (I) and outputs (O)" (Brewer and deLeon, [2], p. 335). Cost minimization is a more precise assessment of the input factors in Brewer and deLeon's definition.

Combat capability includes such concepts as: combat readiness, a high level of training, the right equipment to do the job, and a mentally prepared fighting force. Some definitions of combat readiness are concerned with military utilization rates of weapon systems, or the percentage of weapon systems that are ready for war, or simply how prepared a military unit is for combat as measured by an inspection team. A well trained and equipped fighting force uses various training methods to keep their skills honed. A well equipped force has an adequate level of equipment that is reliable and technologically superior to the enemy. A combat capable fighting force should also be mentally prepared for combat, have high morale and camaraderie, and a strong culture that rewards achieving the desired mission outcomes.

These two ideals--efficiency and combat capability often conflict. When this happens policy makers must determine whether efficiency or combat capability will take precedence.

POLICY ALTERNATIVES

We now turn to a discussion of policy alternatives, using USAF examples to illustrate how efficiencies can be gained and measured. The initiatives are (1) privatization of USAF functions, (2) promotion of competition between USAF facilities and other government entities or civilian contractors, and (3) continuous improvement of USAF processes.

Option 1: Privatization of USAF functions

Privatization is "...enlisting private energies to improve the performance of tasks that would remain in some sense public" (Donahue, [5], p. 7). The USAF performs many functions "in-house" such as building, vehicle and aircraft maintenance, financial management, medical care, fire fighting, and security. Many of these tasks could be performed by the private sector. Many privatization examples already exist within the USAF. Most building janitorial functions are performed by private contractors rather than military or civilian defense employees. Also, some maintenance functions of newly acquired defense hardware are accomplished in the private sector. This option demands a much larger and wide-scaled review of USAF functions to privatize all activities that would yield a cost savings and would not negatively impact wartime capability.

Privatization decisions must consider combat capability. Kettl [14] argues for more privatization, but cautions against privatizing "core functions." At the same time, the USAF must guard its ability to provide the appropriate surge capability. The USAF is moving towards purchasing private sector products and processes where possible. This shift from militarily unique products and services will both increase military access to the national industrial base and support the growing trend towards privatization of public sector services, both in this country and abroad.

Given the policy initiative of privatizing, how should the USAF manager decide whether the efficiency gained from

privatizing outweighs any possible impact on combat capability? We suggest the use of traditional private sector financial analysis to compare public and private sector operations. If financial analysis suggests that the public function performs much less efficiently than the comparable private sector function, then the option of privatization should be considered. This option may be particularly attractive if the privatization does not impact combat capability and valid private sector comparisons are available.

The continuing revolution in government accounting has made possible, for the first time, the financial comparisons of public and private sector functions. We use a simple example to illustrate. Using financial data compiled by the Defense Financial Accounting Service, we compute several financial ratios for a large government owned bookstore and compare them to similar ratios of two private booksellers, Crown Books Inc. and Barnes and Noble Inc. The data for these corporations is available from *Compustat.*

Financial ratio analysis is a technique used in the private sector to compare the operations of firms. This technique facilitates the analysis of differently sized organizations within the same line of business. Ratios measure liquidity, asset management, and profitability. (See Harrison and Horngren, [10] Chapter 15). In this example, we focus on asset management. Table 1 shows the asset management ratios a large government owned bookstore relative to Crown Books and Barnes and Noble. The results show that asset turnover a large government bookstoreis much lower than that of its private sector counterparts. Asset turnover measures how well an entity uses its assets to generate sales. Low turnover implies that larger amounts of assets are needed to generate a given level of sales. In this particular case, a low asset turnover may mean that the entity keeps a lot of inventory relative to its peers. This assertion is supported by the inventory turnover findings. A large government owned bookstore inventory turnover is much lower than its rivals. Together, these two findings may indicate that inventory policy at the public entity may be driving up its costs relative to its competitors.

Other ratios in Table 1 support this conclusion. A large government owned bookstore has a low sales to net working capital ratio and a very high liquidity ratio. Both are indications of high levels of current assets like inventory. The entity also has low accounts receivable turnover, meaning that it does not collect very rapidly for the sales that it does make. All of these ratios together point to a need to examine asset management policy.

Option 2. Competition Between USAF and Other Government or Civilian Contractors

This initiative examines how efficiencies can be gained by facilitating competition between USAF functions and other government entities or civilian contractors. This competition may cause USAF providers to become more efficient or lose work to their competitors. Prior to several years ago, private contractors were not permitted to compete in many of these areas. Furthermore, competition between government entities was not possible because of the lack of prices for internally transferred government goods and services. Transfer pricing regulates the cost of internally manufactured goods and services. For example, a Navy shipyard may manufacture

its own anchors. Suppose the customer, the operational Navy command, had the choice to pay for the anchors through a financial transfer of their cost to the shipyards or had the ability to buy the anchors from a non-Navy manufacturer. The shipyard workers would have the incentive to do it at the least cost. The Navy would be able to make a cost and quality comparison between externally supplied anchors and the anchors made by the shipyard. A decision could then be made to buy them by selecting the cheapest supplier with the best quality anchor. Recognize that under current procurement rules such a choice is not possible. The anchors would be supplied by the Navy shipyard. The shipyard would build them with funding from its own budget rather than from a fund transferred from the customer, or if contracted out, the lowest bid contractor would be selected.

Another example of competition can be found at the USAF maintenance facility at Ogden AFB, in Salt Lake City, Utah. It has a major landing gear repair operation that is well suited to repair many types of aircraft. Competition between the Navy and the Air Force to make repairs on jet fighters like the F-18 or the F-16 is aimed at inspiring repair facilities to minimize costs through more efficient operations. To incentivize workers, financial rewards for efficient work could be given. The incentives need not concentrate solely on financial rewards. For example, competition might be fostered through "winning" a reserved parking spot that was conveniently located near their crowded workplace. This could be an incentive to improve output or reduce costs.

To effectively compete, credible and relevant costs and prices must be determined. Private sector corporations use transfer pricing as a basis to determine internal prices and costs. One way to facilitate transfer pricing in the public sector is through a revolving fund. A revolving fund is a financial tool used to transfer charges between public organizations. Currently, the DOD uses the Defense Business Operations Fund (DBOF) as its revolving fund. It was formed by the 1991 Defense Authorization Bill and merged the Stock and Industrial Funds into one large fund (The Defense, [3]). As of 1994, DBOF contains $85 billion that allows certain organizations to transfer the charges for products between them (DOD Comptroller, [4]). The cost of non-value added activities are also highlighted because visible prices are attached to those activities.

This revolution is also being carried forward by the growing emphasis on ABC methods in the accounting community. These methods tie the costs of production or services more closely to the activities that drive the costs. (See Hilton, [11] Chapter 5). Before DBOF and ABC, the costs of many requested goods and services were "hidden" to managers. With visible costs, managers may decide whether a product is really needed before requesting it. If costs are too high, the manager or commander can shop elsewhere for the product or do without. In a related study, Eldenburg [6] concluded that making costs visible to physicians reduced the cost of health care.

The DBOF, as currently employed, has many restrictions that interfere with true market-like incentives. One of the most significant limitations is the utilization of legislatively established rates, rather than market prices or unit cost, as a transfer pricing policy (OPM, Unit Cost Resourcing, [17, 21]). Legislative controls on prices and lack of profit incentives impede the efficient allocation of resources within public

organizations. A public organization that is allowed to make, retain, spend and distribute a profit as management determines may further improve the efficiency of these organizations.

Option 3: Continuous Improvement of Existing Operations

Improving overall USAF efficiency is an important organizational goal, especially during military downsizing. Open competition and privatization are alternatives that may help to improve efficiency. However, these policy alternatives may be inappropriate for many USAF functions. Combat capability demands that some USAF functions be done in house. The issue thus becomes how to do a more efficient job on these functions. The historical focus of public fiscal activities has been on expenditures and "zeroing out" one's budget, rather than on reducing costs (Gansler, [7]). As Donahue [5] argues, cumbersome rules and procedures associated with public procurements contribute to the lack of efficiency.

One can get a rough measure of overall efficiency by allocating the total USAF budget to a unit of output like aircraft hours flown or number of air crews. For example, with a $85 billion budget in 1993, a 5% savings would be about $4.25 billion. If the USAF can keep its annual flying hours constant at 2,905,000, then some efficiencies may occur. In this example, if the savings could be achieved, then policy makers could use the savings for other valued opportunities within the DOD or other federal programs.

Knowledge of total costs as revealed through modern management information systems and innovative accounting practices can help managers at lower organizational levels to accurately track the true cost of producing output. This is an underlying assumption of ABC (Stevenson and Barnes, [20]). With accurate information about the cost of activities, these costs can be reduced. Additionally, when managers begin to see the costs of requested products, they may re-evaluate the need for the products and reduce their requests thereby making costs decrease for the same level of output. Cost knowledge may be useful in discovering value added activities from non-value added activities as well. By eliminating non-value added activities, total cost may decrease. A decrease in total costs will help an organization become more efficient and allow the cost savings to be used elsewhere.

Financial analysis can also help public entities improve. With regular records of accounting performance, comparisons such as those made with a large government bookstore can illustrate areas where improvements can be made. The earlier example points to asset management as a potential problem area. Comparing its inventory policies to those of its private counterparts may reveal some ways that a large government owned bookstore could reduce inventory costs, for example.

Having accounting records also facilitates rewarding employees for good performance. Table 1 shows that the sales per employee at a large government owed bookstore are greater than the sales per employee at either Barnes and Noble or Crown Books ($220,000 versus $100,000 and $180,000, respectively). This is an indication that the USAFA Bookstore is probably at an efficient staffing level, and that its employees are productive. Where management needs to focus its attention is on asset management.

If efficiencies can be generated, employees should be rewarded. Gainsharing is a program used to allow federal employees to share in savings that result from cost reductions. This program allows employees to share personally in a percentage of the savings they generate. When efficiencies can be identified, measured costs are likely to decrease. The gainsharing program within both the mission and support sides of the USAF may see cost saving ideas increase and pay-outs for these ideas increase.

IMPLEMENTATION OF INITIATIVES

There are several factors influencing implementation of any major initiative. These factors include: source, clarity and support for the policy, complexity of the administration, incentives for the implementors, and resource allocations. Policy makers and policy implementors are normally different actors with different goals and motivations. In this section, we briefly discuss the major issue associated with implementation of the previously discussed initiatives.

Privatization. This initiative has high level support and its currently very trendy. For this reason, political hurdles are surprisingly small. Privatizing remains complex, however, because an adequate basis for comparison between private and public organizations is extremely difficult to derive. Financial analysis blunts this criticism but does not remove it. The allocation of resources becomes an issue with this alternative because a public good is being supplied by a private organization. Privatization often may mean that certain government facilities get less use. Constituents may adversely react to the closing or reduction of government facilities feeling that their local economy may suffer from lost jobs and lower tax revenue. Also, having the private sector deliver a public good opens up a debate concerning the true function of government. Lastly and perhaps most significantly, some functions shouldn't be privatized because of combat capability concerns.

Competition Being able to successfully implement this initiative depends upon having an accounting system in place that provides the visibility into costs needed to make comparisons among various providers. The DBOF system has political support at the highest levels within the USAF, DOD, and Congress. High level support makes policy implementation easier. Provisions for DBOF were approved in the 1991 Defense Authorization Act. But, the administrative execution of that 1991 Act has been dismal (GAO/AIMD-94-7R [8]). There is no central organization overseeing DBOF, the accounting mechanisms are not in place, and the GAO has made complaints about cash management (GAO/AIMD-94-7R [8]). Additionally, the DBOF was first implemented with two goals in mind: cost reductions and market-like efficiency (DOD Comptroller, [4]). To date, many market-like incentives are still absent. Legislatively established prices and other controls are significant political hurdles that block the way to efficiency. The issue is whether DBOF will provide market-like efficiency incentives or will it simply be used as a budget reduction tool. There is support at the top levels for DBOF, but support for it at lower organizational levels is essentially non-existent (Seiden, [19]). If market-like efficiency is a true goal, then actual implementation will become much more complex as the DOD gropes with adequate incentives to encourage worker support. Perhaps top managers must relinquish some

direct financial control to push decision-making down to lower levels. For example, commanders could be given the power to make procurement decisions and be held accountable for financial performance.

On one hand, implementing competition should not harm combat capability. DOD managers, when given the ability to choose suppliers, will theoretically choose the low cost option, assuming the quality of the product is sufficient. When government suppliers choose transfer prices that are too high, customers will have justification to find other private suppliers. During times of combat, however, some private firms may choose not to do business with the USAF due to the risk of delivering goods to a combat zone for example. From a combat capability perspective, keeping an adequate number of suppliers who can deliver the goods and services needed during times of conflict is a crucial concern. This option could potentially decrease the availability of DOD suppliers and hurt US. combat capability. If DOD suppliers cannot improve efficiencies to remain competitive, then policy makers may decide to subsidize them in order to have sufficient surge capability. In addition, preferred supplier lists, the shrinking defense industrial base, bureaucratic restrictions, and capital intensive projects all limit the number of potential suppliers of goods and services to the USAF.

Continuous Improvement Without motivation, DOD workers have little incentive to become efficient. In many cases, perverse incentives may encourage inefficiency, such as trying to secure a bigger budget for non-value added activity. Part of the motivation to improve may come from increased competition form both other government providers and from civilian contractors. Part of the incentive may come form the threat of having their function privatized. Incentive for improvement may also be derived from rewards for improvements in performance.

CONCLUSION

In this study, we examine three policy initiatives aimed at increasing efficiency in the USAF. We also introduce financial analysis as a means to compare the operations public and private entities. Privatization, competition, and continuous improvement are all necessary tools as the Air Force and DOD are forced to become more efficient without sacrificing combat capability. We contend that management tools such as ABC and financial analysis will play a growing role in the selection of these initiatives. The key to success, however, is in having the adequate cost visibility so that comparisons can be made and rewards for improvement can be given. Thus, the efforts currently under way to reform DOD accounting procedures must continue.

The opinions expressed in this study are those of the authors and do not necessarily reflect those of the Department of Defense, the Department of the Air Force, the United States Air Force Academy or any other government agency.

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TABLE 1

This table shows a comparison of the financial ratios of the Government Owned Bookstore and the two private firms, Crown Books and Barnes and Noble.

Ratio	USAFA Bookstore	Crown Books	Barnes and Noble
Asset Turnover *(sales/assets)*	**0.3**	**1.5**	**1.5**
Inventory Turnover *(sales/inv)*	**0.3**	**4.0**	**3.7**
Receivables Turnover *(sales/accts. rec)*	**0.9**	**74.3**	**64.7**
Sales to NWC *(sales/net working cap)*	**0.3**	**2.6**	**7.3**
Current Ratio *(curr assets/curr liab)*	**16.5**	**2.6**	**1.5**
Debt Ratio *(tot liab/tot assets)*	**0.06**	**0.36**	**0.63**
Sales Per Employee *(in thousands)*	**$220**	**$100**	**$180**

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THE FUTURE OF SOF ACQUISITION: IS IT A GROWTH INDUSTRY?

Lieutenant Colonel Randolph A. Mathews

INTRODUCTION

"The clear and present dangers of the Cold War made the need for national security commitments and expenditures obvious...today the task of mobilizing support for national security priorities has become more complicated."

National Security Strategy, 1994

Yogi Berra, the venerable American spokesman and prognosticator stated, "the future ain't what it used to be." Both our world and our view of it have dramatically changed in the last five years. The threat of war with massive Soviet forces, or a nuclear exchange across the poles has been replaced with a complex array of new security challenges unimaginable only ten years ago. While our relationships with Russia and the many new democracies of the former Soviet Union are good, the successor states are fraught with economic and political tensions as they come of age. Transnational threats such as narcotics, refugee flows, terrorism and the proliferation of weapons of mass destruction pose significant problems and challenges to United States security policy and strategy. As a result, we Americans have had to reassess our national priorities; foreign and domestic policies; and, as a consequence, how we allocate our defense resources. As the dust is now settling from this assessment and reprioritization, we can see that the scope and focus of defense materiel acquisition has significantly changed. This paper will explore this change, and the efforts within the Department of Defense (DoD) and the Special Operations Forces (SOF) to deal with the new realities facing defense.

A HISTORICAL PERSPECTIVE

"Good defense is not cheap defense."

President Dwight D. Eisenhower

The title of this paper questions if SOF acquisition is a "growth industry." The question is more complex than it initially appears, and therefore cannot be properly answered in a single word. It is more constructive to seek an answer by examining where it was, is, and where it is going. First, a historical view: from 1984 through 1994, the research, development and acquisition (RDA) accounts represented an average of 24% of the total Defense Department budget (Defense Total Obligation Authority). Put another way, the Department of Defense invested between 19% (FY 1994) and 33% (FY 1984) of its defense budget in modernization efforts. On average, this represented a split of 13% to research and development activities and 11% to

acquisition of end items.[1] Our national security strategies supported this significant modernization effort, which paid great dividends in the dissolution of the Soviet threat and the military successes in Grenada, Panama, and the Persian Gulf. Indeed, the successes of the Gulf War were a mixed blessing for modernization: the United States had an internationally televised showcase for its technologically superior weaponry, giving glowing evidence that technology works, but the fact that our current technology so overpowered the opposition augured against further expensive modernization efforts.

THE CURRENT DEFENSE ACQUISITION SITUATION

"Now, with the DoD procurement budget reduced...it is critical that...[we] adopt cost reduction in current and future weapons and support systems as a primary objective."

Defense Science and Technology Strategy, 1994

Looking at the past provides a basis of comparison for today's situation, where RDA amounts to 18% of the overall Defense Department budget, of which the acquisition portion has shrunk to 4%.[2] This, however, does not represent a reckless reduction. Secretary Perry has methodically sought to place the inevitable reduction in overall defense spending into focus with his five principal priorities:

- Implement the bottom-up force structure;
- Protect the force to sustain a strong readiness capability;
- Redirect the modernization program to sustain a strong science and technology program, invest in next-generation systems, focus on near to medium requirements for theater missile defense, maintain a strong intelligence program and maintain selected elements in the industrial base;
- Execute business more responsibly and effectively; and
- Reinvest defense dollars in dual-use technology.[3]

The first two items demonstrate DoD's resolve to preserve an adequate and capable force structure. In the area of SOF, there has been no significant change to active force structure as a result of the bottom-up review. Nevertheless, the Commander-in-Chief of the United States Special Operations Command (USSOCOM) is committed to preserving the SOF force structure, now considered to be stretched thin by the wide variety of missions facing SOF in today's unstable world. The implication of preserving force structure and readiness is that resources, which previously could be identified for modernization, are now allocated against other priorities. The last three items address the future emphasis for defense acquisition and, as the focus of this paper, will be addressed in more detail later.

[1] *All figures obtained from the respective Department of Defense Future Years Defense Plan.*

[2] *Ibid.*

[3] *Testimony of Gary L. Denman, Director, Advanced Research Projects Agency to the House Appropriations Committee, April 12, 1994.*

As part of his effort to implement Secretary Perry's priorities, the Deputy Secretary of Defense asked the military departments, in August 1994, to determine possible savings from restructuring or cancelling the following programs:

- New Attack Submarine;
- DDG 51 Destroyers;
- Advanced Amphibious Assault Vehicle;
- V-22 Osprey (in which SOF is a key participant);
- RAH 66 Comanche helicopter;
- Advanced Field Artillery System;
- Tri-Service Standoff Attack Missile;
- Joint Primary Aircraft Training System; and the
- F-22 Fighter.

He has stated that, "readiness, sustainability and quality of life may require us to shift resources from some other [budget] priorities."[4] This clearly signals a further reduction in our major end item *acquisition* efforts, but is not inconsistent with Secretary Perry's priority to redirect modernization toward science and technology programs. In real terms, the federal, defense, and acquisition budgets are all declining. This can be interpreted as either the bellwether of a continuing acquisition decline, or the basis for a future, comprehensive (albeit smaller) modernization program. From the viewpoint of defense acquisition, the latter interpretation appears to be supported by examining ongoing and planned efforts in the acquisition arena.

The Deputy Secretary's request has reinforced the fact that DoD must seek other viable avenues by which it can maintain essential elements of the industrial base and preserve readiness through techniques such as service life extension programs, upgrades to existing systems and preplanned product improvements (P3I). Although these techniques and methods have always been a part of the comprehensive defense acquisition program, they were previously pursued less often than new procurement. The military departments, however, are now anxious to preserve their technological edge by any means, and therefore upgrades currently enjoy a renewed emphasis. In the case where the budget (and especially RDA) dollars must be carefully husbanded, upgrading capable equipment rather than replacing it with new equipment may provide the most "bang for the buck."

THE CURRENT SOF ACQUISITION SITUATION

"The shift in focus from the Cold War and an overall decrease in the size of the defense budget has led to a major reevaluation of the entire USSOCOM modernization program. This has resulted in a much leaner, affordable and balanced modernization program."

General Wayne A. Downing, Commander-in-Chief, USSOCOM

Thus far, discussion has been oriented toward the larger Defense budget. In the particular case of the Special Operations Forces (SOF), it is instructive to examine the relationship between its budget and RDA accounts. Since its

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[4] *Deputy Secretary of Defense Memorandum for Members of the Defense Resources Board, Subject: Additional DRB Program Alternatives, August 18, 1994*

establishment as a separate entity eight years ago, the SOF budget (Major Force Program 11), although representing approximately 1% of the overall defense budget, has historically had few of the funding decrements which have plagued the conventional forces. However, that immunity from reduction has ended. For the 1995-1999 period, SOF RDA was reduced $1.3 billion, or 33% from the previously planned levels. The future is no brighter. A glimpse into the SOF program shows a change in the RDA share from 40% of MFP 11 in Fiscal Year 1992, to 23% in Fiscal Year 2001.[5] Since it is apparent that, as with the overall DoD budget, SOF acquisition accounts are shrinking, specific steps must be taken to keep SOF modernization efforts viable.

SOF RESPONDS TO THE CHALLENGE

"There is no ideal solution...one must select that which seems best from the most varied aspects and then pursue it resolutely."

Field Marshal Erwin Rommel

The SOF acquisition community has implemented many belt-tightening measures to maximize the effect of the now scarce investment funds. There are traditional measures, such as stretching out schedules to spread the investment, minimizing the impacts of reductions on any given year, or cancelling a program to use the funds on higher-priority programs. Neither of these approaches are as meaningful, however, as a concerted and renewed effort to carefully evaluate the true value and cost-effectiveness of a materiel solution to a requirement. It is only by judiciously challenging the requirements and improving the acquisition decision processes that we can make the most of our RDA dollars. In the past, it has been said that the Joint Requirements Oversight Committee (JROC) "never saw a requirement they didn't like." Times have changed for the JROC and for the SOF community. The Commander-in-Chief, U.S. Special Operations Command has the authority to approve any SOF-peculiar materiel requirements, and has recently refined the requirements review and approval process to focus not just on the individual requirement, but its impact across and among all systems in a given mission area. If the capabilities and requirements of an entire mission area are considered, it may prove that existing systems can be improved or modified to fill additional requirements. Selective upgrades to existing systems may be more cost-effective than new weapons systems, thus freeing up additional, scarce resources for other high-priority items.

The foregoing does not negate the fact that modernizing with new systems is still necessary, and often the most desirable or cost-effective solution. In the broad view, SOF require mobility platforms; command, control, communications, and intelligence (C3I) systems; and support equipment. The current program provides for new mobility platforms such as the Mark V Special Operations Craft, the Naval

[5] *Figures taken from appropriate years' Program Objective Memorandum extracts.*

Special Warfare Rigid Inflatable Boat, and the V-22 Osprey aircraft. New C3I systems include the Special Operations Command Research, Analysis, and Threat Evaluation System (SOCRATES), the SOF Tactical Assured Connectivity System (SOFTACS), the SOF Intelligence Vehicle (SOFIV), and the Multi-Mission Advanced Tactical Terminal (MATT). Support equipment covers a wide range of new items from the SOF offensive handgun to the SOF Planning and Rehearsal System (SOFPARS). Within these key acquisition programs, the effect of reductions has required major restructuring. However, as the world security situation continues to change, the materiel requirements likewise continue to evolve. There will doubtless be a need in the foreseeable future for some level of new systems acquisition.

As the Defense Department, and by direct extension the SOF, is charged with an ever-increasing mission (witness the humanitarian, peacekeeping, and police actions in the daily news) on a decreasing budget, there is an increased emphasis in the Defense Department and within the SOF community in the area of selective upgrades, service life extension programs, P3I and horizontal technology insertion. These approaches allow selective improvement or maintenance of existing systems, and integration of emerging or more modern technology at appropriate and affordable levels to keep a proven system technologically superior to the threat. Within SOF, examples of this approach include radar, infrared detector, and center wing box upgrades for our aircraft; and the Mod 1 navigation, propulsion, and communication upgrades to the Mark 8 SEAL Delivery Vehicle. It is critical to note that upgrading proven systems inserts the newest technology into the force structure more quickly than developing a new platform or system. In the case of technology, the challenge is to put it into the hands of the SOF while it is still new, allowing our fighting forces to keep the technological edge.

INNOVATIVE ACQUISITION METHODS

"Shrinking defense budgets dictate that we can no longer afford defense-funded, defense-unique solutions to our requirements. We must utilize the economies of scale and technology innovation of commercial industry."

Defense Science and Technology Strategy, 1994

The defense acquisition system has taken a good deal of public as well as internal criticism regarding its unresponsiveness and inertia. The Defense Department is using a variety of methods *within* the defense acquisition system to overcome some of the perceived shortfalls and expense of the traditional process. These approaches include: procuring non-developmental items (NDI)/commercial, off-the-shelf (COTS) items; cooperative programs; leveraging other programs; and design-to-cost contracts.

In the name of "reinventing government," there has been a good deal of recent publicity about the change in emphasis from military

specifications and design specifications to commercial and performance specifications. In fact, the use of commercial specifications and commercial products has been a part of the defense acquisition tool kit for some time--in the form of NDI/COTS. The term NDI/COTS is a generic reference covering materiel available from a wide variety of sources, with little or no development effort required by the government. In the SOF arena, there has been success in meeting materiel requirements with commercial (militarized or ruggedized appropriately) items, adapted or modified military systems, and combinations of existing commercial and military components. This approach is a favorable acquisition strategy, as it significantly reduces developmental costs, often reducing those investments to simply obtaining test samples or prototypes and the required test and evaluation for suitability. Examples of this approach for SOF systems include: Mark V SOC, SOF offensive handgun, underwater GPS, and intra-team radios. The current interest in exploiting dual-use technologies also adds additional emphasis on COTS. One of Secretary Perry's priorities is to reinvest defense dollars into dual-use technologies; this refers to technologies, processes, and products that have both military and non-military applications. The goal is to achieve militarily superior technology in a manner which benefits both classes of products. As the SOF community capitalizes on this thrust, it will be better prepared to defend its investment budget, and to maintain a viable modernization effort.

Another acquisition strategy which has more recently come into favor is "design to cost (DTC)." This method provides industry with a requirement couched in terms of performance, with the focus on cost and performance trade-offs needed to define an affordable system meeting or exceeding required performance levels. The DTC ideal is to achieve a proper balance between development, production, and support costs. In today's environment of constrained budgets, SOF will rely more upon this methodology when NDI/COTS materiel solutions are not available. DTC and concerted efforts to educate government and industry program managers that cost overruns are a relic of the past, with fixed or restructured budgets and programs the rule for the foreseeable future, will assist in controlling program and life-cycle costs.

SOF acquisition has, and will continue to use other service programs as a vehicle to produce derivative SOF-peculiar variants of common materiel. This method, reducing SOF program overhead and R&D costs, leverages the economic buy quantities of the larger service programs, and provides some commonality for continuing support. Additionally, it provides industry the economies of scale and a base over which to spread their R&D and up-front investments. Current examples of leveraged SOF programs are the V-22 Osprey, Quiet Knight, the MH 60K, and the MH 47E helicopters. As the services continue to develop systems with potential SOF application, we should expect more of these leveraged programs.

Similar to the leveraged program concept is the cooperative program. This is yet another method to increase the effect of our RDA investments and leverage developing technology available elsewhere. In a cooperative program, risk and cost are shared between two or more agencies or governments. For example, the Office of the Assistant Secretary for Special Operations and Low-Intensity Conflict executes a counter-terror technology development program. The program has twenty government agencies and three foreign governments participating, which benefit by the shared costs as well as the end product technology.

SCIENCE AND TECHNOLOGY BASE

"We are not the only nation with competence in defense science and technology. To sustain the lead which brought us victory during DESERT STORM, ...we must invest in the next generation of defense technologies."

William J. Perry, Secretary of Defense

In addition to the classical, end-item-oriented acquisition programs, it is essential to maintain a viable science and technology base from which to exploit emerging and promising technologies. Two programs which are useful examples of DoD's efforts to nurture technology are the Independent Research and Development and the Advanced Concept Technology Demonstration programs.

Independent Research and Development (IR&D) is a program which provides an incentive for industry to pursue research at its own expense and risk, with the hope that a portion of the research cost will be recovered against current or future contracts. A 1988 Defense Science Board study reported that "there is probably no other mechanism that is more effective in developing and inserting technology into defense systems than IR&D."[6] Congress inserted language into the 1992 Appropriation bill to raise the split for government payment from 80 to 100 per cent by 1995, which should provide additional impetus for bringing new technology into SOF during difficult budgetary times.

Yet another method of previewing promising technologies "on the cheap" is the Advanced Concept Technology Demonstration (ACTD). These "fieldable prototypes" are a precursor to an acquisition program, which can assist in refining user and developer understanding of new concepts and capabilities, and provide a smoother transition from development to operational utility. When ACTDs are executed with militarily significant quantities, forces are better prepared to rapidly incorporate new systems. The demonstrations provide savings in two ways: first, detailed requirements are established *before* invoking the formal acquisition process (or formal program documentation), and secondly, a sound basis is provided for tailoring entry into the acquisition process. ACTD are an especially important path for introducing new technology when small quantities are required, as is often the case with SOF.

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[6] *The Role of Demonstration Approaches in Acquisition Reform, Larry Lynn, Acquisition Review Quarterly, Spring 1994.*

Finally, there is Secretary Perry's initiative, the Revolution in Military Affairs (RMA), in which SOF is represented by the Close Battle and Low-Intensity Conflict task forces. This initiative is intended to provide an "over-the-horizon" view of the world situation and military requirements for the mid-future (2020). The RMA is seen as a way in which the DoD can realize dramatic improvements in military effectiveness and combat potential. It encompasses aggressive development and incorporation of highly advanced technology (previously referred to as the Military Technical Revolution), doctrinal innovation and organizational adaptation to employ these emerging technologies and opportunities. It will help DoD and SOF focus efforts on the most promising combinations of technologies and doctrine for future forces. While primarily a intended as a defense and technology strategic vision, it does recognize a need to continue developing militarily significant technologies.

CONCLUSION

"My pledge...is to have the best trained, best equipped and most effective forces in the world. But to do this, with reduced resources, we have to manage it right. This time we have to manage it right."

William J. Perry, Secretary of Defense

The future of SOF acquisition will bring with it several inevitable facts. First, there will be fewer new start programs. Upgrades, modifications to existing platforms, SLEP and P3I will replace new systems as the first choice for satisfying new requirements. There will still be new start programs, but they will be the exception, rather than the rule. This reduced level of activity is already reflected by a second fact: there will be fewer defense contractors. The headlines have reinforced this fact--witness the recent mergers of major defense contractors. Matters of market share, efficiency, and economy have made this consolidation and downsizing inevitable, but not entirely unhealthy. The next fact, that there will be less funding for each program can be seen in some of the acquisition strategies and methods addressed earlier. Contracting instruments and contract types will reflect the need to maximize dollar value and eliminate "no-value-added" activity. Finally, the capstone: reduced resources will require better decision processes. Both DoD and SOF recognize the need to make careful, but innovative acquisition decisions. These decisions must expedite the process without sacrificing the safeguards which ensure that the department fields the finest possible materiel to the troops. The fiscal realities and the lessons of total quality management point to streamlined processes, acceptance of program risk, and an intense scrutiny of each decision.

While generally the forecast for future Defense acquisition is not as bright as in previous years, the SOF community is seeking out every opportunity and venue to keep the SOF modernized and capable. As new roles for SOF materialize daily, so do opportunities for new technology application and force enhancement. The challenges are

to carefully consider each and every requirement, each and every technological innovation or application; determine how, within the constrained resource environment, they fit relative to other opportunities and requirements; and lastly satisfy them by the most efficient or cost-effective means possible.

As has been outlined, SOF acquisition is still in business. There are ongoing and planned acquisition programs well into the next decade. While SOF will continue to "do business," it must sharpen its focus, embrace the principles espoused by the Secretary of Defense, and make the difficult decisions required to comply with fiscal reality. If SOF is successful in separating the important "needs" from the many "wants," and applies some of the methods previously outlined, it will be able to continue the SOF modernization program. As Babe Ruth noted, "yesterday's home runs won't win tomorrrow's ball game." Given careful management and innovative approaches, one concludes that while neither defense acquisition at large, nor SOF acquisition in particular may be considered a "growth industry," SOF acquisition will remain viable well into the twenty-first century and does, indeed, have a future.

PUBLIC LAW 101-510: ITS IMPACT ON THE DEFENSE CONTRACTING COMMUNITY

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ABSTRACT

The past two years have seen a resurgence in the performance of aerospace and defense companies. Profits and cash flow are up dramatically, resulting in higher stock prices. This is due largely to cutbacks in head count as well as reductions in capital investment and R&D spending. As we move into the second half of the decade however, conditions do not appear optimal for continued profit growth. Although work force attrition will continue, the largest cuts are behind the industry while capital equipment and R&D spending could decrease even further, thus impacting future growth. Given the inevitable pressure on revenues resulting from defense budget cuts, it appears likely that operating and financial performance will be negatively impacted, accelerating the trend towards industry consolidation. However, there is another reason why industry profitability and cash flow might be significantly impacted relating to changes in legislation that we believe may not be fully understood by defense contractors.

INTRODUCTION

The Demise of the M-Accounts

Prior to FY 90, appropriations that had lapsed, thus reaching the end of their legal availability, were then placed in what was known as the Merged or M-accounts. The funds in these M-accounts could then be used to finance other projects, such as contract closeouts and equitable adjustments. Many observers, particularly those on Capitol Hill, believed that M-account monies were being redirected to fund other programs that had not received the desired levels of resources through the authorization and appropriation process. Therefore, beginning with the FY 90 defense authorization bill, M-accounts were eliminated. The effect on acquisition programs since that time has been two fold. Funds originally obligated and not disbursed have now been "cancelled", thereby eliminated from being used to pay for outstanding deliverables.

In addition, if government personnel determine that products and services previously billed and paid for were disbursed from cancelled appropriations, contractors could be required to refund those monies on a temporary basis. In both cases, government contracting officers are being forced to ask for additional current year funding to pay for requirements which were believed to have been fully funded.

The severity of the problem cannot be overestimated. Based on experience, we believe that since fiscal year 1991 hundreds of millions of dollars in previous year obligations and disbursements may be at risk. To the casual observer these numbers, when compared to the defense budget as a whole, may seem inconsequential. But when one narrows the comparison to just the R&D

and procurement budgets, the impact becomes much greater.

Given projected spending levels over the next few years, DOD could find itself exceeding the 1% restriction on the use of current year funds to pay cancelled year bills (per Public Law 101-510). However, legislative relief may be necessary if this ceiling is exceeded.

The financial consequences for contractors could be equally burdensome. With revenues decreasing and a significant part of the industry restructuring already complete, contractors have been looking to preserve cash flow as a way to fund defense related acquisitions and pursue non-defense oriented diversification. Any disruption in cash flow generation could severely hamper these efforts. Contract closeouts likewise could be delayed or invalidated if deliverables and/or services are determined to have been paid incorrectly. The delays of contract closeouts on supporting subcontractors will have an addition ripple effect on prime contractors. Prime contractors cannot close out their government contracts until all of their respective subcontracts have been closed out. Administrative costs associated with keeping contracts and subcontracts open as well as delaying final payment of contracts for subcontractors have a significant negative impact on cash flow. Even after all contract deliverables have been shipped, contracts can take in excess of ten years before receiving final close out approval.

The Impact of the 1989 Defense Management Review

The ongoing streamlining of Defense Logistic Agency (DLA) payment functions has contributed to the confusion. As a result of the 1989 Defense Management Review conducted by then Secretary of Defense Cheney, DLA established a finance center in Columbus, Ohio to consolidate contract payment responsibilities previously handled by 20 regional sites. Contract administration continues to be handled by five regional Defense Contract Management Districts (DCMD). A March 1994 GAO report (GAO/NSIAD-94-106) documented the difficulty DLA has had in implementing this consolidation.

At the request of Sen. John Glenn (D-OH), Chairman of the Senate Committee on Governmental Affairs, the GAO researched some $392M out of a total of $751M in returned checks from contractors during a six month period ending in April of 1993. The report noted that of the $392M, some $305M were over payments related to invoices being paid without recovering progress payments (58% of total), duplicate payments (12%) and other errors (30%). The report goes on to indicate that virtually all of the overpayments were discovered by contractors.

DLA has strengthened its reconciliation team at the Defense Finance & Accounting Center (DFAS), in Columbus, Ohio to deal with this problem. In all fairness to DFAS, however, the GAO report further noted that the Center has been severely hampered by a huge backlog of problem contracts (estimated at 6,600 in total), the departure of experienced employees (necessitating the hiring of new personnel who require time to get up to speed) and the accelerated transfer of contracts to the Mechanization of Contract Administration (MOCAS) management system from other DFAS locations, which overwhelmed the ability of Center personnel to manage these contracts.

The Impact on Current DFAS Policies and Procedures

In particular, we believe problems associated with the transfer from other systems such as the Acquisition Management Information System (AMIS) to MOCAS to be of critical importance. AMIS is used to monitor contracts out of Wright Patterson AFB and other Air Force facilities. In order to more efficiently use AMIS data, a special application known as the Contractor Obligation and Liquidation Tracking System (COLTS) has been developed. COLTS data output offers summary analysis regarding the status of obligations and disbursements. The data identifies the potential problems associated with unliquidated obligations (ULOs), under/over payments and contract closeouts.

Designed by TASC (The Analytic Sciences Corporation) for the Air Force Materiel Command / Aeronautical Systems Center (AFMC/ASC), COLTS has the ability to map out the relationship between the relevant account appropriations, contract modifications, accounting classification reference numbers (ACRNs), contract line item numbers (CLINs) and shipment / invoice numbers, thus providing the user with a desk top tool for resolving contractual/financial disconnects.

Derivation of the correct ACRN / CLIN relationship per the contract is critical in determining what products and services have been paid correctly in addition to being able to forecast the impact of appropriation cancellations on the funding of future deliverables. When MOCAS does not provide an ACRN/CLIN relationship, these relationships must be derived manually. The process used to develop the ACRN/CLIN relationship requires that the contract and all modifications be available and that the individual developing the ACRN/CLIN relationships review in sequential date order each obligating document. Some contracts have an excess of 1,000 modifications and it will take a substantial amount of time to manually develop these respective ACRN/CLIN relationships. The problem is expected to worsen as new contracts transfer in from other payment systems, supplementing the 400,000 plus contracts currently active in the MOCAS system.

As the GAO noted, contractors have assumed the bulk of responsibility for identifying incorrect payments. One company reportedly resorted to setting up a special account in which to hold known overpayments in lieu of expected demand letters; at one time, the balance of this account was approximately $1.9M. But what happens when contractors receive a demand letter relating to overpayments they were not aware of?

The contractor receives a summary notice and limited documentation stating the amount of the requested refund to be returned within thirty days to avoid the imposition of interest charges. Yet, the contractor has no access to the MOCAS system to understand how the justification for the demand amount was derived. This information however is available through the government contracting officer and identifies contract obligations, disbursements, progress payments, recoupments and internal balancing adjustments.

The major supporting documentation within the MOCAS system consists of the Contingent Liability Register (CLR), Contract History and Contract Abstract. The CLR presents a contract summary of the ACRN level of obligations and unliquidated

obligation balances (the difference between obligations and disbursements by ACRN). The Contract History provides a transaction level summary of obligation and disbursement activity for a contract. The balances from these transactions are then reflected in the CLR. The Contract Abstract is a summary of activity for a contract and is the source of information about ACRNs, CLINs, shipments / invoices and other administrative data. Receipt of this information and other supporting documentation from the contracting officer will assist the contractor in:

- identifying inconsistencies between the contract documentation and what was posted in DoD financial records
- correcting mathematical errors in obligations, disbursements, progress payments and associated recoupments
- determining justification for internal balancing adjustments.

CONCLUSION

With the elimination of the M-accounts, the accelerated transfer of contracts into DFAS-Columbus, the departure of experienced personnel and the planned consolidation of different military department payment systems into one centrally managed by the DFAS, payment problems will likely become worse. It will be incumbent upon defense contractors and contracting officers to devote sufficient resources to manage the challenges that will inevitable arise from having to do more with less.

Measuring Operational Contracting Cost, Output, and Quality Together

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ABSTRACT

Performance unit costing (PUC) considers the cost of operations relative to performance units. In procurement, performance units represent completed actions, adjusted for quality by an index measuring such aspects as customer satisfaction, increased use of commercial products, or attaining goals in competition or socioeconomic programs. In this way, cost, output, and quality considerations are traded off. Applying PUC represents a significant shift away from simply measuring a single productivity factor (such as procurement administrative lead-time) or from using quantity or dollar volume as a workload indicator. The Logistics Management Institute (LMI) uses PUC to integrate the measurement of outputs as opposed to inputs, quality as determined by the customer, and the cost of operations — a crucial process, especially in a time of budget reductions.

Before implementing any measurement system, it is important to perform some sensitivity analysis to determine the true incentives generated by that system. Especially when combining measures, managers must take great care that the ranges of performance and weights applied to each measure lead to desired outcomes. Furthermore, contract specialists must understand the effects of actions that they take in order for a system to have the power to motivate improved performance.

The conclusions in this paper are important to contract managers and others concerned with resource allocation. Regardless of the performance evaluation system chosen, managers need to come to terms with the measurement and motivational issues raised in this paper.

INTRODUCTION

Measurement systems have long been a staple management tool for business, with bottom-line profit often being considered the primary indicator of performance. If contracting offices worked in a competitive environment, offering services to those customers willing to pay for them on a fee-for-service basis, a bottom-line evaluation might be suitable. [1,2] However, for monopoly operations, such as the provision of government services in a not-for-profit environment, the bottom line may not be sufficient or even calculable. Regardless of this situation — or perhaps because of the need to be more accountable to the taxpayer for results — demand for better measurement systems for government operations has increased. The idea that government should run like a business — or at least adopt businesslike principles — is not new, but it has recently gained momentum. In addition to the Presidential and congressional compaigns of the 1990s that embraced these concepts, they are supported by many other specific actions. For instance,

- Congress passed the Chief Financial Officers (CFO) Act in 1990, which requires 14 of the largest agencies to develop measurement systems that strengthen system accounting; enhance internal audits; incorporate future costs of decisions; improve management of cash, credit, inventory, and debt collection; and charge customers true costs; [3]
- the Department of Defense (DoD) Comptroller [4] and the Office of Management and Budget (OMB) [5] have issued guidance to carry out the CFO Act;

- Vice President Gore's *Report of the National Performance Review,* 1993, [6] calls for creating a government that measures performance, puts customers first, creates competition within government, is more market-oriented, and is decentralized;

- Congress passed the Government Performance and Results Act of 1993, [7] which emphasizes the need for performance measures tied to organizational strategic plans and objectives;

- the Governmental Accounting Standards Board [8] has developed a uniform approach to reporting service efforts and accomplishments that considers cost per unit of outcome;

- the National Academy of Public Administration [9] and the American Society for Public Administration [10] have passed resolutions supporting additional performance measurement efforts that monitor program quality and outcomes as part of an overall system aimed at improving the performance and credibility of major public programs;

- Executive Order 12862, "Setting Customer Service Standards," of September 11, 1993, [11] requires (among other things) identifying customers, surveying them to determine the kind and quality of services they want and their level of satisfaction with existing services, posting service standards and measuring results against them, benchmarking customer service performance against the best in business, and providing customers with choices in both the sources of service and the means of delivery;

- Executive Order 12931, "Federal Procurement Reform," of October 13, 1994, [12] requires, among other things, a focus on measurable results, increased attention to understanding and meeting customer needs, and an increase in the use of commercially available items; and finally,

- several executive agencies have a number of initiatives under way to comply with the statutes that have been cited and to improve agency operations, such as the procurement performance measurement model of the Procurement Measurement Action Team, discussed below. [13]

Since quality and customer service are inextricably related aspects of any measurement system, failing to evaluate them with efficiency or production may result in suboptimized overall performance. Classically, efforts to apply business management to government operations have resulted in pressing the government manager to provide the current level of service with a reduced budget. Now the goal is even more difficult to attain: providing *increased* service while still reducing the cost. But when we enter this arena, we face difficult problems. It is important to consider three points regarding service quality as viewed by the customer:

- The only criteria that count in evaluating service quality are defined by customers. Specifically, service quality perceptions stem from how well a provider performs vis-a-vis customers' expectations about how well the provider *should* perform.

- Service quality is much more difficult for customers to evaluate than product quality, because of its inherently subjective nature.

- Customers do not evaluate service quality solely on the basis of the outcome of a service rendered; they also consider the *process* of service delivery (for instance, how involved, responsive, and friendly the service provider is). [14]

Because measuring customer-driven quality requires comparing customers' expectations to actual performance, government measurement

systems designed without a customer service dimension, adequate in the 1980s, are no longer so. In fact, the customers or stakeholders of the contracting process may be several disparate groups of people: broadly defined, customers are not only the project officers and program managers, but also contract managers, upper management, the agency head, Congress, and the public at large. (For our purposes, the project officer probably serves as the best example of a primary customer. It should be assumed that the project officer is carrying out the goals of the program as directed by the Congress, which represents the general public, and the executive agency.)

Since resources (usually tax revenues) are not available to meet customers' expectations beyond a certain level, managers need also to measure the efficiency with which they are providing services. Contract managers have often performed this function by measuring the number of contract awards made by each contract specialist or how quickly contracts are awarded. When these measures are used in isolation, however, the effect may be an unfortunate one — the hurried production of a high number of poor-quality contracts that require expending an extensive effort (often by a different group of people) to correct their inadequacies. This can truly suboptimize overall performance and waste valuable resources.

To avoid the use of measurement systems that could lead to these counterproductive results, the performance unit costing (PUC) approach combines a number of measures. [15] This concept is being applied in fields other than procurement by the

- Air Mobility Command, which uses it to consolidate various measures such as hauling cargo, moving passengers, and providing pilot training;
- Military Traffic Management Command, which uses it to measure the quality of transportation of goods;
- National Aeronautical and Space Administration (Ames Research Center), which uses it to combine cost, output, and quality as a total performance measurement framework; and
- Department of Energy Southwest Power Administration, which uses it for performance budgeting.

This paper starts with a discussion of historical contracting measures, next describes the PUC model development in a contracting environment, and then amplifies it to show its sensitivity to the measures and weights selected by managers.

THE MEASUREMENT BASELINE

Over the years, others have proposed many separate measures for application to the procurement area.

Commercial Purchasing Benchmarks

The Center for Advanced Purchasing Studies of the National Association of Purchasing Management produces benchmarks to be applied to purchasing in various industries. [16] A group of purchasing professionals from each industry develops a list of common industry benchmarks. They collect and report data on the common benchmarks and compile summary statistics for association members and academe. Some measures applicable to both the public and private sectors are shown in Exhibit 1.

Malcolm Baldrige Award Criteria

The procurement function in an organization, like the rest of the organization, needs to have a quality-management system. One well-accepted way of defining and evaluating a quality

Exhibit 1.
Summary of Commercial Purchasing Benchmarks

Benchmark	Median	Mean	Range	Number
1. Total purchasing (the dollars spent with suppliers) accounted for ___ percent of sales revenue.	34.5	35.2	10 – 58	20
2. The expense of operating the purchasing function was ___ cent per dollar of sales.	0.2	0.33	.06 – 1	20
3. It costs ___ cents to purchase a dollar of goods or services.	0.75	1.05	.25 – 3	21
4. There was one purchasing employee for every ___ company employees.	149	226	26 – 1,660	19
5. There was one purchasing employee for each $ ___ million of sales.	34.9	61.6	7.8 – 538	21
6. There were $ ___ million of purchasing department purchases per purchasing employee.	11.8	11.4	2.9 – 27.2	21
7. Each professional purchasing employee managed $ ___ million of purchasing department purchases.	18.1	19.3	3.7 – 47.9	21
8. There were ___ active suppliers per purchasing employee.	83	89	21 – 297	21
9. Minority-owned businesses received ___ percent of total purchase dollars.	2.2	3.2	1.1 – 9.1	21
10. Small businesses received ___ percent of total purchase dollars.	26.3	24.3	7 – 42	8
11. Women-owned businesses received ___ percent of total purchase dollars.	2.6	2.4	.9 – 4.4	21
12. Electronic Data Interchange (EDI) was used to process ___ percent of company purchase dollars.	5.1	6.6	.26 – 21	21
13. The purchasing department made ___ percent of the total purchases.	87.5	85.8	44 – 96.2	20
14. After a purchase request was received in the purchasing department, it took ___ days for a supplier to receive a purchase order.	6.5	11.4	5.1 – 25.5	7

NOTE: The first numeric column contains the median value (i.e., the point where half the industries were higher and half lower) for the number of industries represented, as shown in the last column. The mean value (the sum of all values divided by the number reporting) and the range of values (the lowest and the highest values reported) for each benchmark are also shown.

system is provided by the Malcolm Baldrige Award criteria. While the information and analysis area is only one of the factors in the Baldrige assessment, we focus on it here because of its inherent linkage to the measurement system. In this assessment, three factors are considered:

- The scope and management of quality and performance data and information used for planning, day-to-day management, and evaluation of quality and operational performance.
- Competitive comparisons and benchmarking to support improvement of quality and operational performance.
- Analysis and use of company-level data related to quality, customers, and operational performance.

The Baldrige standard's emphasis on having a sound, systematic procedure is shown by its goal of mobilizing an organization towards

- a sound, systematic prevention procedure refined by means of evaluation and improvement cycles;
- a system integrated into all major business areas and all support areas;
- excellent (world class) results in major areas and good-to-excellent trends in all support areas; and
- producing evidence that results clearly are caused by the approach used. [17]

We find these considerations to be important and incorporate them in the design of the measurement system set forth in this paper.

Procurement Executive Association

The Procurement Executive Association (PEA), composed of key Federal civil agencies' acquisition officials, established a Performance Measurement Action Team to assess the state of the current system, identify innovative approaches to measuring performance, and develop strategies and recommendations for measuring the health of agency acquisition systems. [13] The team members developed an expanded and enhanced "balanced scorecard" [18] including 14 measures in five areas: financial, customer, internal business, innovation and learning, and employee empowerment. They measure strength in these areas by using a combination of survey results and workload and financial data collected by existing information systems.

For example, they use a customer survey to determine satisfaction with on-time delivery, planning activities (including establishment of lead-times and acquisition milestones), and ongoing communication. Other measures are the number of actions per employee, purchasing department costs as a percentage of contract dollars awarded, and the ratio of dollars saved or costs avoided as a percentage of contract dollars obligated. While this model has been tested at selected civil agency sites, it has not been fully validated across the entire government spectrum. The PEA team believes that the recently completed test indicates great potential for using this model to measure the health of procurement organizations. In at least one agency it is being used to replace the traditional procurement management review program. [19]

We believe that the balanced scorecard approach as applied to procurement functions is an appropriate response to including multiple measures in a single performance measurement model. Trading off one perspective area against another and motivating superior performance will continue to be a challenge as the balanced scorecard is applied in practice.

Historical Contracting Measures

Within government contracting offices, a variety of performance measures have been used over the years to measure organizational performance. One paper on procurement performance led to the development of the performance

measures covering quality, effectiveness, and efficiency that are set forth in Exhibit 2. [20] While an office may not want to use all of the measures in each category, selecting a few of them may provide a start toward developing a comprehensive performance measurement system. So far, however, we are unaware of any effort to combine the measures into an inclusive single measure.

Corporate Model

James P. Morgan has described a Purchasing Productivity Index that combines several measures. [21] The first is the proportion of total purchases completed through preferred methods: corporate or cooperative divisional agreements, in-house purchases, and competitive procurement. The second is the average of the vendor quality rating and timeliness-of-delivery ratings. The third is the profit contribution, calculated as the total of net savings, cost avoidance, earned discounts, and transportation savings in proportion to total purchases. These three factors are divided by 100 and then multiplied by one-third of the value of the performance factor. The performance factor is a measure of the divisional performance as a proportion of the corporate performance in dollars per line item, dollars per person, and dollars per buyer.

Because all measurement systems motivate behavior, the goal is to encourage optimum behavior to maximize performance. When they combine measures, managers must take great care that the ranges of performance and weights applied to each measure lead to outcomes that they desire. For example, in the just-described Purchasing Productivity Index, since profit contribution seldom could be expected to top 20 cents on the dollar, a purchasing division director might find it much more fruitful to concentrate either on preferred methods or on the vendor's performance, which can provide much higher scores. If this outcome is acceptable to the upper level managers, the performance measurement system is correctly motivating the division director. But if it is not desired that more concentration be placed on preferred method and less on profit contribution, the system may need to be changed. Before implementing any measurement system, even in a pilot application, it is important to perform a sensitivity analysis, as discussed later, to determine the true incentives that will be generated by that system.

Measurement Baseline Summary

In applying performance measures, agencies must consider a number of other issues as well. One of them is that, because the organization and responsibilities of contracting offices may vary, managers cannot compare the performance of one office with that of another unless everyone involved understands the differences in organizational tasking, accounting systems, and measurement methodologies. But the measures *can* be used with great effectiveness to assess the performance of a single office over time.

The measures for quality, effectiveness, and efficiency and the measurement systems that have been described have not usually been coordinated or consolidated into a measurement model resulting in a single numerical value that provides a unified measure of operational contracting cost, output, and quality together. Unifying such measures, as we describe below, provides organizations with a yardstick that empirically demonstrates performance over time.

PUC APPLIED TO CONTRACTING

Performance unit costing (PUC) considers the cost of operations relative to performance units. Performance units represent completed contract actions, adjusted for quality by an index measuring such aspects as customer satisfaction and attainment of goals for competition or socioeconomic programs. This approach trades off quality, output, and operational cost considerations.

Exhibit 2.
Suggested Performance Measures

Measure	Description/Benchmark
Quality	
Customer satisfaction	Evaluate selected items from customer survey, considering both positive and negative comments
Solicitation	Determine the quality of the solicitation
Proposals/competition	Assess procurement publicity and attainment of competitive goals
Evaluation/negotiation	Evaluate the professionalism with which proposals are evaluated on both technical and business bases and the use of the resulting information in negotiations
Organizational placement	Assess visibility of office; should be equivalent to that of program offices and high enough to command management attention
Socioeconomic goals	Determine extent to which goals are achieved
Training	Determine number of hours spent in training (e.g., 40 per person per year)
Turnover	Examine turnover exceeding 20 percent per year
Management information	Evaluate extent and usefulness of management information systems
Effectiveness	
Customer satisfaction	Evaluate selected items from customer survey, considering both positive and negative comments
Processing time	Determine length of procurement administrative lead-time and success in meeting processing time goals
Consolidation of orders	Assess extent to which similar programs are combined to rationalize processing
Obligations	Consider degree to which time goals for obligating funds are met
Workload	Evaluate level and uniformity
Delinquent deliverables	Calculate percentage; should not exceed 20 percent
Closeout	Determine contract closeout backlog; should not exceed the annual number of awards
Efficiency	
Total number of contracts awarded	Count the number of contracts awarded per year
Number of contracts awarded per specialist	Divide the annual count by the number of contract specialists
Total value	Total the dollar amount of contracts awarded annually
Value of contracts awarded per specialist	Divide the summation of annual dollar amount by the number of contract specialists
Total cost of contracts operation	Total the annual operating cost (direct and indirect)
Cost of contracts operation as a percent of total award value	Divide the annual operating cost by the summation of annual dollar amount
Cost of contracts operation as a percent of agency budget	Divide the annual operating cost by the annual agency budget

Source: [20]

The most difficult task when developing a PUC measurement approach is selecting the quality index factors. One method we suggest is to assemble a group of customers and ask them to define the factors they believe essential for quality.

In earlier work, the authors, together with others at LMI, developed a PUC contracting quality index by assembling a team of highly experienced procurement management professionals and having the team jointly list desired items pertaining to the procurement process, as seen by principal customers, including managers of the process. From this long list of desirable factors, the team members then individually ranked the importance of the listed items by assigning either 3, 5, 7, or 9 points to each item. The combined result — the average for each item — was used to create a list of the key items (or "quality factors"), that indicates how they might be measured and the relative weights assigned to them by the team.

Exhibit 3 is an illustration of a set of quality factors and weights developed by the authors as an example to be used for this paper. In this example, customer satisfaction would be measured through the use of surveys. We think that a short postcard-type survey should be used, requesting information on issues such as timeliness, value received compared to funds expended, receipt of the correct product or service, and professionalism of the contracting staff. This survey would be completed at the time of purchase request receipt (only those items applicable to planning), at the time of contract award, and at the time of delivery. We include a measure related to increasing the use of commercial sources as an additional measure in the example. Finally, we have included the attainment of socioeconomic program and competition goals as example measures.

Once the quality factors and their weights are established to the satisfaction of the customers, work force, and managers, they can be used to develop the PUC model for the activity. This model combines the quality factors with the operational cost of the work unit and the total number of completed output units.

In establishing the relationship between cost, output units, and quality, the manager must carefully consider the emphasis to be placed on each area and how the factors will relate to each other. If the formula is simply the cost (C) divided by the output units (O) multiplied by the quality index (I) [performance unit cost = C/(OxI)], any proportional change in one factor will have the same impact on the performance unit cost as any similar change in another factor. However, if we want to put additional emphasis on quality, we can increase the importance of

Exhibit 3.
PUC Contracting Quality Factors — Example

Quality Factor	Measurement	Index Weight
Customer satisfaction — timeliness, value, correct product/service, contracting professionalism	Customer survey	0.60
Increasing use of commercial sources	Percentage of proposals received compared to sources solicited	0.20
Attainment of socioeconomic program goals	Percentage reflecting degree to which goals are achieved or criteria satisfied	0.10
Attainment of competition goals	Percentage reflecting degree to which goals are achieved or criteria satisfied	0.10
Total		1.00

that factor in our equation by raising it to a power, say by squaring it [performance unit cost = $C/(OxI^2)$]. This is the example used in the balance of this paper. (Some examples of the application of the PUC approach with this added quality emphasis are shown in Exhibit 4.)

The situation in Column A of Exhibit 4 shows low output (900 output units) and poor quality (a quality index rating of 0.60 out of 1.00), resulting in a total of 324 performance units. This situation results in a performance unit cost of \$15,432 each. Holding total organizational cost constant while improving both quality and output, as in the example in Column B, reduces the per unit performance cost to \$6,457. Finally, the example in Column C shows the change resulting from improving the quality index to its highest level while holding all other factors constant, resulting in a performance unit cost of \$5,000. In these examples, producing additional output and increasing the quality index achieves lower performance unit costs. Managers may also affect the other item in the equation — cost — which would also change the PUC results.

So far in this discussion, "contract action" has been the output unit measure. Depending on the office being measured, this term could take on a variety of meanings. In some situations, an office might choose to measure only initial contract awards. However, most contracting offices would choose to add some of the following: delivery orders, option exercises, modifications (funded, unfunded, and administrative), terminations, basic ordering agreement awards, and closeouts. These items would usually be given various weights based on their perceived level of difficulty. Initial contract awards are also often categorized by dollar value, type of contract, solicitation method, or some other measure of complexity. The exact definition of "contract action" should be determined by the office being measured. But whatever the definition, it must be thoughtfully selected so as to reflect the incentives desired by management.

The PUC value of an organization may be affected by outside variables as well as by actions taken by the managers or other members of the organization. For example, if the office's workload is reduced through downsizing or for any other reason, unit costs will initially increase as a certain amount of fixed overhead cost is spread over fewer output units. In the long run, short-term fixed costs are also variable and can be affected by management action. If such outside forces affect the organization during a measurement period, they must be taken into consideration separately.

Exhibit 4.
Performance Unit Costing — Examples

	Possible Outcomes		
Factors	A Low Output Poor Quality	B High Output Better Quality	C High Output Perfect Quality
Output units (O)	900	1,000	1,000
Quality index (I)	0.60	0.88	1.00
Performance units (PU) = ($O \times I^2$)	324	774	1,000
Cost (C)	\$5,000,000	\$5,000,000	\$5,000,000
Performance unit cost = C/PU	\$15,432	\$6,457	\$5,000

Exhibit 5.
Sensitivity Examples

Factors	Baseline	Example 1	Example 2	Example 3
Output units (O)	1,000	850	1,000	1,000
Quality index (I)	1.00	1.00	0.85	1.00
Performance units (PU) = (O x I^2)	1,000	850	722.5	1,000
Cost (C)	$5,000,000	$4,000,000	$4,000,000	$4,000,000
Performance unit cost [PUC = C/(O x I^2)]	$5,000	$4,705.88	$5,536.33	$4,000
Unit savings (loss) (baseline performance unit cost minus example performance unit cost)	$0	$294.12	($536.33)	$1,000
Total savings (loss) (unit savings x PU)	$0	$250,002	($387,498.43)	$1,000,000
Gainsharing (50% of total savings)	$0	$125,001	$0	$500,000

COMBINING COST AND QUALITY — PUC SENSITIVITY ANALYSIS

Once the PUC formula is developed and the quality factors and relative weights are agreed upon, a combination for considering both cost and quality will be in place to measure and motivate staff performance. It is essential that managers understand the dynamic forces that this combination may produce and the effect they have on motivation, to be sure that they are consistent with organizational objectives. For this reason, before any new measurement system is prototyped, a sensitivity analysis should be conducted to ensure that the system's elements will work synergistically to improve organizational performance. Also, if the system is to be most effective, the staff members must find that there is something in it for them. Whether this "something" is a gainsharing program,[1] or some other reward (as encouraged by the Federal Acquisition Streamlining Act of 1994 [22]), the basis for awarding it will be a lower performance unit cost. (Although the motivational effects of gainsharing remain controversial, many people think that the ability to receive a portion of the savings will encourage a great deal of innovation among work teams. This paper assumes that such a program is in existence.)

Under this measurement system, three variables are considered simultaneously: the number of units produced, the quality index, and the total cost. Because quality at *any* cost is not realistic in these restrictive budget times, a balance is necessary. Playing out these and other alternatives may identify less-than-optimal results. If managers of a procurement office are not satisfied with the measurement scenarios, they should change the weights used in the PUC formula, in order to encourage the desired behavior. Managers can change the emphasis by changing the weights in Exhibit 3 so that an area they value more highly has more weight. Or they can consider other factors. To determine the formula's motivational aspects, it is important for managers to test it under various scenarios. Three examples are shown in Exhibit 5.

As can be seen from the exhibit, the level of quality is very significant. Any change in value of the quality index (since it is squared in the formula) makes a large change in the perform-

[1] Gainsharing programs are used to motivate team members by providing them financial awards for improved performance. Although known by many names and having infinite variety in the details of their applications, they typically take a proportion (say, 50 percent) of the team's operational performance savings and distribute it among the team members.

ance unit cost. With the formula used here, even with a 20 percent reduction in the operating cost of the office, and assuming maintenance of the same output, quality cannot drop by more than 10 percent to maintain nearly the *same* PUC value {$4,000,000/[1,000x(.90)^2] = $4,938.27}.

Since the quality index is a key variable, another area that managers must review is the determination of the index weights themselves. Given the information in Exhibit 3, meeting the customer satisfaction factor is three times as important as increasing the use of commercial sources and six times as important as attaining goals in either socioeconomic areas or competition. Exhibit 6, using the same factors as Exhibit 3, shows how measurement tradeoffs affect the quality index.

To provide the basic illustration of the quality index, Column A of Exhibit 6 shows the ideal case, with each measure scored at 100 percent, resulting in a total score of 1.00. Column B is the same example, but with each factor scored at 90 percent, resulting in a score of .90. Columns C and D achieve the same score, but in different ways. The example shown in Column C indicates a poorer job of achieving customer satisfaction goals, while Column D shows a potential problem in meeting socioeconomic and competition goals. To you as a manager, are the examples in Columns B, C, and D all equally pleasing? If not, you need to reevaluate the weights for each area.

Finally, the staff member working with the situation in Column E, which may be the most realistic, must decide what actions to take to most improve the score for the office (and that person's reward as a participant in the team's gainsharing program). This will involve determining the tradeoff between the number of points available in each category versus the difficulty in achieving them. It may be easier to attempt to achieve the 0.1 additional points by increasing the use of commercial sources than it is to earn 0.09 points by making all customers satisfied. Managers must be confident that the employee's choice will be the one the managers desire.

Another concern with any measurement system is a change in the staff's behavior that may result from collection of a particular data element. For example, would a contract specialist attempt to limit the sources sought to known previous offerors in order to increase the proportion of commercial proposals? If so, that measure may be poorly designed and a correction would be needed. Adding another measure, such as considering the total number of new sources (previously not doing business with the government) solicited, as compared to the number

Exhibit 6.
Quality Factors with Alternative Quality Outcomes

Quality Factor	Index Weight	A		B		C		D		E	
		Score	Value	Score	Value	Score	Value	Score	Value	Score	Value
Customer satisfaction	0.60	1.00	0.60	0.90	0.54	0.87	0.52	1.00	0.60	0.85	0.51
Commercial sources	0.20	1.00	0.20	0.90	0.18	1.00	0.20	1.00	0.20	0.50	0.10
Socioeconomic goals met	0.10	1.00	0.10	0.90	0.09	1.00	0.09	0.50	0.05	0.90	0.09
Competition goals met	0.10	1.00	0.10	0.90	0.09	1.00	0.09	0.50	0.05	0.90	0.09
Total	1.00		1.00		0.90		0.91		0.90		0.79

of proposals received from such companies, may correct the otherwise counterproductive behavior.

DATA COLLECTION

To institute a measurement system, certain data must be collected, usually on a monthly basis. To apply the PUC method described above, the manager must know the

- customer satisfaction survey data, as described above;
- contracting operation's total cost, including indirect costs;
- number of contract actions awarded;
- socioeconomic program goals;
- degree of attainment of the socioeconomic program goals;
- competition goals; and
- degree of attainment of the competition goals.

It might be assumed that any contract action will be treated as having the same value as any other contract action. But, unchecked, this procedure may lead contract specialists to execute a large number of unfunded administrative modifications. To avoid such a result, the contract manager may establish categories of contract actions to provide additional weight to those perceived to add the most value to the operation. If this is done, it multiplies the data collection effort accordingly, since data must be collected for each category.

If other items from Exhibit 1 or 2 are desired for part of the contracting office measurement system, data collection requirements must be adjusted accordingly.

Finally, it is very important that the measures be consistent from period to period. For example, a change in the calculation of charges for the square footage occupied by the contracting office (when there has been no change in the size of the office itself) would cause a change in the PUC value that did not reflect a change in the office's efficiency of operations. By holding the definition of the measures constant, or by carefully adjusting the PUC value on the basis of known differences, year-to-year progress can be evaluated. As noted above, definitional and operational differences usually mean that the PUC values achieved by offices in different agencies may not be able to be compared with one another.

CONCLUSION

The PUC concept can be useful for contracting offices to combine the factors of quality, output, and cost. The ultimate outcome of a single PUC value helps the office to track its performance over time. It can help managers develop a procurement measurement system that will provide those incentives to the work force that management wishes to promote.

The examples in the paper show that all elements of the measurement system are important and must be thought through carefully before being introduced. These elements include the

- items to be measured (e.g., customer satisfaction or attaining competition goals);
- definitions of the customer and of each item to be measured (e.g., contract actions);
- weight applied to each item in the quality index (or any index);
- weight applied to each item in the PUC formula (the degree of importance attributed to each item);
- gainsharing payout (or other reward) calculation for improved performance; and

- ability to accurately record the original data.

The importance of considering carefully all these elements is great regardless of the measurement method used — not just for PUC — and it is imperative that a sensitivity analysis be performed to determine just what incentives will be created by any proposed system of measurement.

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REASONS FOR COST AND SCHEDULE GROWTH

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ABSTRACT

Programs to acquire major weapon systems often end up taking longer and costing more than planned. Delays in schedules may leave U.S. forces without needed capabilities and vulnerable to enemy weapons, if the system is not completed on time. Delays often translate into higher cost, which creates further problems. Weapon system costs have been growing both from generation to generation, and, within a given system, from plan to realization.

This paper highlights cost and schedule experience of programs to acquire tactical missiles and tactical aircraft since the 1960s. By looking at past programs, the paper examines hypotheses about what separates the kinds of programs completed on schedule and within cost plans from those that suffer from schedule and cost growth.

On average, the total program cost growth for tactical missile programs is substantially higher than for tactical aircraft, and development cost growth and development schedule growth are also high.

The histories of the tactical missile programs were examined to determine the reasons for schedule and cost growth. Keys to preventing schedule growth in development are technical realism and willingness to make tradeoffs. Programs with high development schedule growth tended to underestimate technical difficulty

Cost and schedule growth measures were also calculated for a sample of seven tactical aircraft. These measures are less dispersed than those for tactical missiles. The aircraft programs tended to receive more management attention and more protection from production schedule stretch than the tactical missiles.

The case analyses indicate that there are many useful lessons to be gleaned from historical perspective, lessons that cannot always be captured in a quantitative estimating relationship. Despite individual differences in programs, the importance of understanding the level of technical difficulty when original schedule and cost estimates are made, of strict phasing and vigorous testing, and of adhering to production plans are borne out by analysis of past strategies and outcomes.

A. INTRODUCTION

Programs to acquire major weapon systems usually cannot follow their carefully-laid acquisition plans in every detail. They often end up taking longer and costing more than planned.

The time required to design and develop major weapon systems has apparently lengthened, and weapon systems often exceed their planned development schedules. A 1990 RAND Corporation study found that programs from the 1970s and 1980s took longer than those from the 1950s and 1960s. The demonstration/validation phase (from Milestone I to Milestone II in the process required by DoD regulations) and the engineering and manufacturing development

phase (measured from Milestone II to the first delivery) each take about a year longer than they used to [1]. A 1992 IDA study found that, on average, systems take one-third longer than planned to progress from Milestone II to achievement of initial operational capability (IOC) [2].

Excessive schedules have two significant negative effects. One is that delays in schedules may leave U.S. forces without needed capabilities and vulnerable to enemy weapons, if the system is not completed on time. The other is that delays often translate into higher cost, which creates further problems.

Weapon system costs have been growing both from generation to generation, and, within a given system, from plan to realization. Growth in the cost of weapon systems appears to be a chronic problem. Of 82 programs examined by IDA in 1992, 66 had experienced cost growth [2].

The defense acquisition community is concerned that programs to develop major weapon systems take too long and cost too much. In 1986, the President's Blue Ribbon Commission on Defense Management (the Packard Commission) called schedule length "a central problem from which most other acquisition problems stem" [3]. Cost growth forces the DoD to revise budget plans, makes systems less affordable, and frequently erodes congressional support for acquisition programs.

This paper highlights cost and schedule experience of programs to acquire systems in two major product categories, tactical missiles and tactical aircraft. Tactical missiles are particularly prone to cost and schedule difficulties, as prior research has shown [2, 4, and 5]. Tactical missiles, while technologically complex, are viewed as being less glamorous than tactical aircraft, and missile programs often do not receive priority. Tactical aircraft are among the most technologically complex products the military buys. They are developed on a custom basis, usually pushing the state of the art. Tactical aircraft development is constrained by size and weight restrictions, and is spurred toward ever-faster goals for operating speeds. Moreover, the physical environment in which these aircraft operate often involves extreme temperatures, high vibration, and G-forces [6].

By looking at past programs, the paper examines hypotheses about what separates the kinds of programs completed on schedule and within cost plans from those that suffer from schedule and cost growth. On average, the total program cost growth for tactical missile programs is substantially higher than for other equipment types, while development cost growth and development schedule growth are among the highest. Development schedule growth for tactical missile programs is high.

B. DATA

The sample consisted of fifteen tactical missiles and seven tactical aircraft. None of the programs in the sample was canceled. The data on these systems were obtained from Selected Acquisition Reports (SARs), from historical memoranda to support DoD program reviews, and from summaries of program data [7 and 8]. Data were current as of the 1992 SARs.[1]

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[1] Only the first version of each system was examined and not subsequent modifications, unless they were considered as separate programs. DoD treatment of modification programs in its reporting and review process has not always been uniform. Sometimes, as in

Cost and schedule growth were examined by comparing actual outcomes with those planned at the Milestone II review, when the commitment for engineering and manufacturing development was made. Outcomes were expressed as a ratio of actual to planned cost or schedule.

The development cost growth (DCG) ratio is defined as:

$$DCG = ADC/PDC,$$

where

ADC = actual development cost, the actual cost to develop the system, measured in millions of FY 1994 dollars from Milestone II to the end of development of the first version; and

PDC = planned development cost, the planned cost to develop the system, measured in millions of FY 1994 dollars from Milestone II to the end of development of the first version.

The production cost growth (PCG) ratio is defined as:

$$PCG = APC/PPC,$$

where

APC = actual production cost, the actual cost to produce the planned quantity of the system, measured in millions of FY 1994 dollars; and

PPC = planned production cost; the planned cost at Milestone II to produce the planned quantity of the system, measured in millions of FY 1994 dollars.

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the case of the F-14, a new version was treated as a new program and went through a new set of reviews and had separate documentation. Other times, as in the case of the F-15, DoD treated the program as one, despite the technical differences between the F-15A/B and the F-15E. When a data source included costs for modified versions, data on production schedules were used to obtain the actual costs for the first version.

If the actual quantity produced was greater than that planned at Milestone II, the numerator was the cost to produce only the planned quantity. If the actual quantity was less than that planned, a price-improvement curve was used to project the cost of producing the planned quantity. In every case, only data on actual costs were included. DoD future planned costs were not used to measure cost growth.

The total program cost growth (TPCG) ratio is defined as:

$$TPCG = (ADC + APC)/(PDC + PPC).$$

Schedule measures were calculated similarly. The development schedule growth (DSG) ratio is defined as:

$$DSG = ADS/PDS,$$

where

ADS = actual development schedule, actual time to develop the first version of the system, measured in months from Milestone II to initial operational capability (IOC); and

PDS = planned development schedule, planned time to develop the first version of the system, measured in months from Milestone II to IOC.

The production schedule stretch (PSS) ratio is defined as:

$$PSS = APS/PPS,$$

where

APS = actual production schedule, actual time to produce the planned quantity of the system, measured in months from Milestone III to the end of production of the planned quantity; and

PPS = planned production schedule, planned time to produce the planned quantity of the system, measured in months from Milestone III to

the end of production of the planned quantity.

The timing of production is based on obligation of funds, not deliveries, because that is the way the plans are made. If the planned quantity has not yet been produced, a linear projection was made based on actuals.

Total schedule growth (TSG) ratio is defined as follows:

$$TSG = (ADS+APS)/(PDS+PPS).$$

TPCG and TSG may be useful in understanding the effect of development disruptions or successes on the total program. For example, we may observe that a program completed development seriously behind schedule, but within its planned cost. While it is possible at that juncture to have a production program proceed as planned, it is also possible that issues of performance, producibility, or maintainability are not completely resolved until after production is underway, adding to production costs.

Table 1 presents cost and schedule growth measures for the sample of fifteen tactical missiles. The programs for which information could be obtained represent a span of twenty years, with FSD start dates ranging from 1962 to 1982. The sample includes tactical missiles from the Army, the Navy, and the Air Force.

Table 1. Cost and Schedule Growth Measures for Tactical Missiles

	Development		Production		Total Program	
Missile	Cost Growth	Schedule Growth	Cost Growth	Schedule Stretch	Cost Growth	Schedule Stretch
Phoenix AIM-54A	1.54	1.94	1.35	1.03	1.38	1.38
AMRAAM	1.76	2.29	1.84	2.73	1.84	2.61
Hellfire	1.22	1.44	1.60	0.99	1.46	1.23
HARM	1.61	1.59	1.51	1.17	1.52	1.33
Sparrow AIM-7F	4.26	2.80	1.58	0.75	1.73	1.57
TOW	1.20	1.45	1.78	3.90	1.71	2.78
Sidewinder AIM-9L	4.89	2.48	2.07	2.29	2.23	2.38
TOW 2	1.39	1.00	0.95	1.02	0.97	1.01
Harpoon	0.90	1.35	1.85	1.66	1.66	1.56
Maverick AGM-65D/G	1.07	1.98	1.45	1.93	1.42	1.95
Sparrow AIM-7M	0.96	1.49	2.04	1.08	2.00	1.26
Sidewinder AIM-9M	2.04	1.01	1.02	0.65	1.10	0.86
Phoenix AIM-54C	1.67	1.46	1.93	0.74	1.89	1.10
Maverick AGM-65A	1.04	1.33	0.99	0.98	1.01	1.09
MLRS	1.02	1.06	0.88	1.06	0.90	1.06
Median	1.39	1.46	1.58	1.06	1.52	1.33

These measures showed a great deal of variability among the 20 programs examined. Programs took from 50 months to 134 months from Milestone II to IOC. Only one of the tactical missile programs was finished on time. The program with the highest development schedule growth exceeded its plan by 180 percent. Two programs came in

under budget, while two others doubled in cost from their Milestone II plan.

Table 2 presents cost and schedule growth measures for the sample of seven tactical aircraft. The sample included the major fighter aircraft programs over the past three decades. The F-14D was omitted, because its experience was much more limited than the others, and in 1992, it was on the verge of cancellation. These measures are less dispersed than those for tactical missiles. Development programs had fairly small schedule overruns, with the F-16 finishing in the time allotted and the program with the most schedule growth, the F-14A, running over by only 18 percent. The highest cost growth index for tactical aircraft was 1.40 (for the F/A-18), versus 2.23 for the tactical missiles.

Table 2. Cost and Schedule Growth Measures for Tactical Aircraft

	Development		Production		Total Program	
Aircraft	Cost Growth	Schedule Growth	Cost Growth	Schedule Stretch	Cost Growth	Schedule Stretch
F-5E	1.05	1.06	0.79	0.70	0.91	0.83
AV-8B	1.40	1.03	0.93	1.94	0.98	1.50
F-16	1.20	1.00	1.08	1.11	1.11	1.06
F-14A	1.53	1.18	1.17	2.08	1.26	1.69
F-15A/B	1.08	1.05	1.19	1.14	1.20	1.10
A-10	1.37	1.09	1.34	1.73	1.37	1.44
F/A-18	1.15	1.09	1.42	1.17	1.40	1.14
Median	1.20	1.06	1.17	1.17	1.20	1.14

C. LESSONS LEARNED FROM MISSILE PROGRAMS

This section highlights the reasons for cost and schedule growth in selected tactical missile programs based on case studies from [10]. The systems discussed here were chosen on the basis of information availability and do not represent a scientific sample. They do, however, include instances of programs with very high and very low cost and schedule growth.

a. Reasons for Schedule Growth in Development

Table 3 summarizes the key program characteristics that led to low or high schedule growth in development. Development is highlighted here, because it clearly represents a program outcome--it is important that the system be finished on time. Schedule growth in production, by contrast, is often a policy variable--e.g., Congress decides to slow the program for budgetary reasons.

Table 3. Characteristics of Missile Programs: Schedule Growth in Development

Program	Percentage development schedule growth	Characteristics
Low Growth		
TOW 2	0%	Follow-on system
Sidewinder AIM-9M	1%	Follow-on system to fulfill goals of AIM-9L Learned from unrealistic estimate of prior system
MLRS	6%	Urgent program Competitive prototype Requirements/schedule tradeoff made in favor of schedule
High Growth		
Phoenix AIM-54A	94%	Problems resolved in development, not allowed to spill over into production Testing delays Delays in aircraft platform
Maverick AGM-65D/G	98%	Funding cut slowed development, allowed technology to catch up Prototype Vigorous testing program
AMRAAM	129%	Prototype showed infeasibility of approach High concurrency, urgent program Rushed testing
Sidewinder AIM-9L	148%	Urgent program, with fly-before-buy strategy Technical problems, with increased development quantity Joint service program, with technical disagreements
Sparrow AIM-7F	180%	Underestimation of technical difficulty (vacuum tube to solid state) Vigorous testing program

Two of the three programs with low development schedule growth—the TOW 2 and the Sidewinder AIM-9M—were modification programs with fairly simple technologies. The other program, the MLRS, was urgent and made a technical tradeoff to meet the schedule. Programs with high development schedule growth included two joint-service programs (AIM-9L and AIM-7F) and two programs with schedule urgency (AGM-65D/G and AIM-9L). Underestimation of technical difficulty was common. In two cases (AIM-54A and AIM-9L), development was slowed to resolve technical problems, in the hope that they would not spill over into production. In the case of the Phoenix AIM-54A, that strategy appeared to be successful. In the case of the Sidewinder AIM-9L, it cannot be definitely stated that the high production cost growth was due to development problems spilling over into production because the AIM-9L also suffered a major production stretchout.

b. Reasons for Cost Growth (Total Program)

Table 4 summarizes the key program characteristics that led to cost growth outcomes, based on the case analyses. As in the previous analysis, programs are grouped into low and high categories.

All four programs with the lowest TPCG are characterized by low stretch in production. Interestingly, three of the four programs in this group were also characterized by urgency. In the case of the MLRS, the requirement was modified to meet a deadline. (The AIM-9M may be something of an anomaly in this group, because it was intended to fulfill the technical goals for the AIM-9L.)

The programs with high TPCG, by contrast, were characterized by stretched production schedules. Both AMRAAM and the Phoenix AIM-54C had high levels of concurrency and rushed testing programs. Both the Phoenix AIM-54C and the Sidewinder AIM-9L were dual-sourced for technical reasons (e.g., to get a better functioning system) rather than principally for cost savings. In the case of the AIM-54C, funding was reduced to move more quickly to the next-generation system, and five years were spent qualifying a second source for only two years of head-to-head competition, with resulting inefficiencies. AMRAAM also had used a dual-sourcing strategy and was produced at less than the planned rate--an expensive combination. The Sparrow AIM-7M also suffered from reduced production funding in order to fund the next-generation system.

D. LESSONS LEARNED FROM TACTICAL AIRCRAFT PROGRAMS

a. Development

Tactical aircraft outcomes in both development and production exhibited less variability than the outcomes of tactical missiles. Development cost growth ranged from 5 to 53 percent, and total program cost growth ranged from -9 to 40 percent. In part, this may be because the sample of aircraft is smaller than the sample of missiles. However, it is also the case that development programs of aircraft appear to proceed more smoothly than those of other types of systems [2 and 5].

Table 4. Characteristics of Missile Programs: Cost Growth in Total Program

Program	Percentage total program cost growth	Characteristics
Low Growth		
MLRS	-10%	Competitive prototype Requirement lowered because of time urgency Mulityear procurement, low stretch
Maverick AGM-65A	1%	Total package procurement with low concurrency Vigorous testing program Low stretch
TOW 2	-4%	Urgent modification program Foreign Military Sales Low stretch
Sidewinder AIM-9M	10%	Learned from schedule problems in AIM-9L program Urgent program, took its lumps in development Low stretch
High Growth		
AMRAAM	84%	Prototype showed infeasibility of approach High concurrency, rushed testing Stretched program, dual-sourcing
Phoenix AIM-54C	89%	High concurrency Dual-sourced for technical reasons Five years qualifying for two years of competition Needed funding for next generation
Sparrow AIM-7M	100%	Competitive prototype, low cost growth in development Needed funding for next generation
Sidewinder AIM-9L	123%	Crash program Dual-sourced for technical reasons Production stretch

Development schedule growth was small in the aircraft development programs. The highest value was 18 percent for the F-14A.

The two programs with the lowest development cost growth are the F-5E and the F-15A/B. The F-5E was a relatively simple development program, building on a commercial system. The F-15 program proceeded smoothly, with relatively few engineering changes. The F-14A had the highest development cost growth, 53 percent. This may have been due to the unusual contracting arrangement, a fixed-price development contract with options for several years of production. Grumman ran into cost trouble and insisted on changes in the contract before it would produce the aircraft.

b. Production

Few studies have analyzed aircraft production. One reason may be that "the production phase is assumed to be less interesting as outcomes at this point are more predictable than during development, and the problems that do occur are generally traceable to faulty decisions made earlier in the program" [6, p. 159].

But from the contractor's viewpoint, production opportunities define the business environment contractors face. A contractor cannot keep going on developments alone. According to Mayer, "without existing or potential production work, contractors scale back investment, reduce staffing, and redirect efforts toward other markets that have a brighter outlook."

As compared with the 1950s, the 1990s have fewer new production starts, fewer production lines open at any given time, and longer production runs, but with smaller total quantity--i.e., a lower production rate. None of these trends, of course, is at all favorable to reducing costs.

During the 1960s, there was a trend toward fewer new production starts. However, the Vietnam War greatly increased the demand for aircraft, and production buys were quite large. The space program also helped to keep those contractors who were frozen out of the new airframe business going. In the 1970s, several new programs started, but annual buys were reduced after the war ended. In the 1980s, many new programs started, but not all of them survived. The 1990s will be a decade where only a few prime contractors for tactical aircraft will survive.

The A-X program has already been canceled, and it appears that the F-22 and the F/A-18E/F may be the only tactical aircraft programs in production by the end of the decade. Several systems currently in production--the F-14, the F-15, and the F-16--are expected to end within the next few years.

Nevertheless, one characteristic of the production environment is that production lines tend to stay active much longer, even as the total number of units produced declines. Table 5 shows the average length of production runs for fighter and attack programs. Continuing these trends and combining it with a trend toward fewer new programs provides further weight to the conclusion that fewer units will be produced per year and that contractors who fail to participate in one of the few new programs will no longer be prime contractors. A model cited in Reference [6] projected that a company would lose its viability as a prime contractor after only 18 months without a contract, after which it would be forced to focus on subcontracting.

Table 5. Average Length of Production Runs for Air Force and Navy Fighters

Years	Length (Years)
1951-1960	9.4[a]
1961-1970	20.0
1971-1980	18.0

Source: Reference [6].
[a] Excludes the F-5 fighter, which was built primarily for export.

In the sample of tactical aircraft, there was considerable variation in production schedule stretch. The F-5E program, for example, produced its planned quantity 30 percent faster than planned, while the F-14A and AV-8B programs were stretched out, producing at about half the planned rate.

With respect to cost, the F-5E came in 21 percent under expected cost, benefiting from a high production rate and technical simplicity. However, both the AV-8B and the F-14A suffered from production stretch, yet exhibited low production cost growth. In the case of the F-14A, slower production was accompanied by funding cuts. The original plan, to produce 463 aircraft in 5.5 years, was recognized early as unrealistic, and the contractor had plenty of time to scale back production facilities. Moreover, the development of the F-14D aircraft occurred at about the same time, and may have helped the contractor cope with costs on the F-14A. In the case of the AV-8B, the program never produced as many aircraft as planned. However, the presence of other, larger programs in the same plant--including the F/A-18 and the F-15--may have helped to contain costs.

The program with the highest production cost growth is the F/A-18, which exhibited production cost growth of 42 percent, despite little production stretch. The F/A-18 originated as the losing entry in a competition to provide a lightweight fighter for the Air Force and the Navy. The Air Force selected the YF-16 in a prototype flyoff over the YF-17. Congress encouraged the Navy to adapt the YF-16 to its special needs. However, the Navy redesignated the YF-17 as the F-18. Technical problems in range, cycle time, strafing, roll, and faulty radar images were identified at the DSARC III meeting. Despite claims that the digital flight control system would eliminate the need to physically change the test aircraft (because changes would be made in the software), the Navy and the contractor made more physical changes to the F-18 than to any other fighter aircraft in the last twenty years [9]. Technical changes, particularly late in development or in production, are expensive.

D. CONCLUSION

This paper discusses research to describe cost and schedule growth patterns associated with the acquisition of major systems, to identify reasons for the growth, and begins to develop a way to anticipate likely growth in development and early production phases. By looking at past acquisition programs, the management policies and circumstances that separate the kinds of programs completed on schedule and within cost plans from those

that experience cost and schedule growth can be determined.

Cost and schedule growth for the tactical missiles in the sample were measured in development and in production. These measures showed a great deal of variability among the twenty programs examined. Programs took from 50 months to 134 months from Milestone II to initial operational capability. Only one of the tactical missile programs finished development on time. The program with the highest development schedule growth exceeded its plan by 180 percent. Two programs were completed under budget, while two others cost more than double their Milestone II plan.

The histories of the tactical missile programs were examined to determine the reasons for schedule and cost growth. Keys to preventing schedule growth in development are technical realism and willingness to make tradeoffs. Programs with high development schedule growth tended to underestimate technical difficulty. Two of the five programs with high DSG also had high overall cost growth. However, in three of the five cases of high DSG, it appeared that a strictly phased approach--resolving problems in development when spending levels are low--resulted in lower levels of overall cost growth. Keys to preventing overall cost growth are correctly estimating the degree of technical difficulty in the programs and maintaining the planned production schedule. Programs that employed a high degree of concurrency, that had to be dual-sourced for technical reasons or that were dual-sourced at less than full rate had high cost growth. In one case, the threat of competition appeared to reduce costs.

Cost and schedule growth measures were also calculated for a sample of seven tactical aircraft. These measures are less dispersed than those for tactical missiles. The aircraft programs tended to receive more management attention and more protection from schedule stretch than the tactical missiles. The highest cost growth index for tactical aircraft was 1.40, versus 2.23 for the tactical missiles.

In two cases (the F-14A and the AV-8B), programs were stretched in production but did not suffer from the high cost growth seen in the missile programs. In the case of the F-14A, this could have been due to a combination of early warning and the presence of the F-14D development program to cushion the blow. When the AV-8B was stretched out, the fact that the F/A-18 and F-15 programs were using the same plant may have helped to spread overhead costs and contain cost growth in the AV-8B program. The program with the highest production cost growth is the F/A-18, which exhibited production cost growth of 42 percent. Technical changes made late in the process contributed to its high cost growth.

E. IMPLICATIONS FOR DOD

In the light of these results, DoD and other personnel who review acquisition programs would benefit from a review method based on detailed information about the strategies and outcomes of past programs. The lessons of history can be used to identify which programs require more detailed examination. The case analyses indicate that there are many useful lessons to be gleaned from historical perspective, lessons that cannot always be captured in a quantitative estimating relationship. For the tactical aircraft, the 1990s will be a decade where only a few prime contractors will survive. If programs are stretched out, contractors are

not likely to be able to cushion the blow by working on other programs.

At the beginning of a weapon system development program, the feeling prevails that that program will avoid repeating the problems of previous programs. Yet cost and schedule growth persist. Despite individual differences in programs, the importance of understanding the level of technical difficulty when original schedule and cost estimates are made, of strict phasing and vigorous testing, and of adhering to production plans are borne out by analysis of past strategies and outcomes.

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DEFENSE INDUSTRIAL BASE

PRODUCT OR PROCESS?

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ABSTRACT

- Present discussions about the Industrial Base deal with the PRODUCTS of the base, regardless of its military or commercial nature. The tally of products in a highly developed economy might go into the millions, well beyond anybody's singular comprehension.

- We overlook the fact that large numbers of products are the result of the relatively few PROCESSES used to make them.

- It is suggested we develop a taxonomy of processes and determine those of national importance for the future position of our nation and concentrate upon the preservation of those processes.

The OBJECTIVE of this paper is first "to justify" and second "to outline" the development of a process taxonomy and in turn develop a new vista from which to view present problems like conversion or dual-use.

The SCOPE of the paper is limited to the fundamental engineering aspects of the process taxonomy. Political-economic aspects are only mentioned occasionally in order to underline their importance and need for further studies.

The PURPOSE of this paper is to suggest a new approach to problems of the Industrial Base and to inspire a dialog on the subject. The paper is not intended to provide a cookbook of how to do things, but rather an invitation to think differently about our challenges.

The BACKGROUND for the paper is provided largely by the changed military-political situation as result of ending the Cold War. Prior to this time, for example in Global War Game exercises, the main question was, "How fast can we increase our military capabilities in case of war or in the case of major materiel losses due to an enemy attack?" But, with the "sea change" of Communism's decline this concern has all but evaporated.

The first question in the euphoria after the end of the Cold War was about the proper utilization of the one-time defense industrial resources for a popularly labeled "peace-dividend": How can we convert our defense industry to a beneficial peacetime production, and well meaning people were eager to suppose the experiences after World War II as a model. But, soon it was recognized that the WWII experience was utterly meaningless. After WWII, a tremendous pent-up demand existed and most of the returning soldiers had real savings to satisfy this demand. In contrast, after the Cold War, not only was there no

pent-up demand , but a considerable over-saturation of the market. Differently expressed, no demand for products, resulting from conversion, existed and the economic situation now and then is not comparable.

We at DSMC, aware of that truth, initiated a pilot study with the Naval Shipyard in Philadelphia. Our question was, "What goods can you produce with your existing equipment, which is presently imported into the United States, and hence, without making competition to existing American producers (working already with low facility utilization)?" The answer was: "We could produce all railroad cars presently imported from Europe and most of the fasteners imported from Taiwan and therefore not produced in the United States."

This pilot study was simply learning tool for us. Unfortunately, we had no opportunity to extend this study beyond the engineering aspects of so-called conversion. To study the economic aspect would have been even more interesting. For example, one could have asked, "If the U.S. yard would have built railroad cars instead of closing, therefore further diminishing the U.S. industrial base, how would you account for for the past investment?" "Should it be considered at its book value or as sunk-cost ... etcetera?"

Slowly, the conversion mania subsided the important questions were excavated: for example, under the heading of "dual-use" and of "military industrial capability," or "reconstituting" in case of need, combined with the desire to stay in the forefront of military-technological capabilities and R&D under the heading of "research without production."

The Office of Technology Assessment of the Congress of the United States responded without delay to the new challenges and provided a series of excellent publications, like "Redesigning Defense - 1991," or "Defense Conversion - 1993." All those publications deal with the contours of high level manufacturing policy for the products needed to defend.

A similar (but commercially oriented) view is taken by the Department of Commerce (DOC). In DOC studies, the products are not as dominant as are the manufacturing entities which produce the products. The Standard Industrial Classification (SIC) codes lists approximately 11,000 manufacturing entitites and the alphabetic index reveals close to 20,000 products (or product groups).

The concern with products is more than natural. It is self evident. Irrespective of the commercial or military domain, regardless if seen from the government point of view or from the point of a private person, not accounting for our position as producer or consumer ... we always concern ourselves with products in the form of goods and services. We want to know the quality of the product and its price. We are talking about the cost effectiveness (value) of different products, of international competitiveness and so forth, ad infinitum.

The number of products major department stores have to offer goes into the millions. We can live with this and do take it correctly as a symbol for a high quality, developed economy and most of us are really <u>not</u> concerned "how" all those products are provided.

And here, the problem begins to fester.

In a free (laissez-faire) economy, the market decides (by buying or not) what the customer wants and the system works to relative perfection, without any government interference. As long as the demand for military goods (during war time or the cold war) was very large, even the defense market worked on a quasi-competitive basis, where supply responded to demand in the oligopsony (a system with one or a few buyers and many competing suppliers). But today those conditions belong to the past. Presently, the demand for military goods is frequently below the economic ordering - quantity (which can be thought of as the minimum sustainable production rate) and hence many defense suppliers are forced out of the market. The Department of Defense reacted to this new status by shifting from "the best buy" paradigm to the more basic "maintenance of certain capabilities." For example, the Navy is concerned to keep one builder of submarines (Groton Electric Boat) and one builder of aircraft carriers (Newport News) relatively solvent. The Air Force Assistant Secretary for Acquisition, Mr. Clark Fiester stated (Airman magazine, February 1995) that "We can no longer afford a separate military industrial base" ... "while producing superior weapons ."

Nothing could describe the changed situation better than Fiester's words. It simply describes reality. The problems are recognized. But, what should be the action-response?

The "possible" action responses will be bounded or be located somewhere between two extremes. The first extreme is to subscribe completely to the laissez- faire philosophy and assume whatever the military ordering quantities will be in the future, the supply side of the market will respond to it and government interference with the private industry will be neither necessary nor appropriate. The second extreme would be to subscribe to a full control of the supply side for military goods through the (re) introduction of a arsenal system (which is tantamount to nationalization of weapons production), at least for those weapon systems which are considered critical to the military posture of the United States. But, since extremes are mostly wrong and hardly ever optimum, a search for a middle position is necessitated. The search for this middle position between the two extremes has two decision engines: Judgment and Knowledge, (two terms which need at least some explanation).

Every decision process has three phases. At the beginning and the end is judgment and in between analysis based on knowledge. Judgment at the first inkling is mostly quite of an abstract nature. It is governed by a tapestry of values, with a singular view toward the future, with our desires and wishes like "we have to stay in the forefront of technology" or "we have to be on the leading edge."

"Judgment - at the beginning" is the goal setter in national and private life. In short, the initial judgment expresses the "I WANT."

After the "I want" is defined, follows the analytical fora: What do I have to know in order to reach the goal described with the "I want?" What resources do I need? How much will it cost to reach the goal?

The analytical part is eminently visceral yet concrete. Everything is measurable and countable: How is the

industrial base structured? What are the value-added processes? What capital/labor ratios are involved?

After the analytical part is culminated, we return to the "judgment at the end:" After the analysis has determined what "I CAN DO" and then its price tag becomes the question: "Am I willing to pay the price?" This is pure judgment (values), unsupported by the middle phase logic.

Judgment - in its most generalized form - will determine the future role of the United States defense establishment and an estimate about the time we will have to reconstitute the capability to produce military goods in the case of an emergency (if such capabilities should be lost). This judgment, like in the past, could be translated into "requirements."

However, I doubt that this judgment can be realized without the knowledge about the industrial base (of this what CAN be done) ... and furthermore, I doubt that this knowledge can be acquired as long as we are talking about "products" regardless of their commercial or military value. We simply have too many products to ever be fully comprehended by analysts or the collector of knowledge.

The conventional wisdom in case of an over abundance of "data" would be to revert to statistical sampling as a supposed representive reality. No question, this could help and the wide collection of statistical data by the Department of Commerce could provide the starting point.

However, I think we could solve the problem of knowledge accumulation much easier by shifting from the products to a consideration of the relative few processes [which in turn are] leading to the incomprehensible abundance of products.

For example, the knowledge of the value added process, of the capital/labor ratio, etcetera, is NOT product dependent, but process dependent and therefore valid for all products subject to the same process.

History of manufacturing supports my suggestion for the shift of our attention from products to processes. Let me give you three examples:

(1) In the long bygone days, for example, a carpenter or furniture maker was the master of four processes: Of cutting wood; of planing wood; of connecting wood, and of finishing wood. With these four processes, he was able to build a wide variety of furniture according to the individual choice of his customers. He might never have built the same piece twice.

(2) Many leading car manufacturers in Europe between 1910 and 1930 were a collection of masters of the different metal-trades: casting; forging; metal forming; leather work, etcetera and with a combination of those activities were able to manufacture luxury cars, buses, trucks, trailers, taxi cabs. Whatever was running on wheels; in small quantities. It was not very efficient, but the mastery of a few processes enabled them to respond to a wide range of demands.

(3) After WWII, when the European ship building industry started to recuperate, almost all shipyards had to be "integrated yards," able to make anything from the hull to the engine, pumps, propellers, cranes and so forth, within their own boundaries. The lack of a supply industry forced them to do this. They were able to do it, because they

had mastered all processes of the metal trades. At this time, the United States ship building industry could already afford to work with "assembly-yards," supported by a highly developed network of subcontractors, specializing in engines, pumps, cranes, propellers and so forth.

I hope those few examples demonstrate:

- As long as we remain masters of relatively few processes, we will be able to build a wide variety of products. For example, as long as we are able to preserve the knowledge embedded in workers <u>and</u> the facilities to weld high-tensile steel, we will be able to build tanks, submarines, landing gears, missiles and everything else for the military and commercial customer -- using mastery of the rudimentary processes as opposed to the more shallow application of pre-fabricated products.

- When we lose specific process capabilities, nurtured in workers using some general tools, we have little chance to reconstitute whenever needed.

I hope my few examples and logic for the concentration on processes instead of products should suffice to wake the readers interest toward my suggestions.

Now comes the difficult part: The <u>ANALYSIS</u> of my suggestions. I will try to <u>outline</u> the analysis in a few distinct steps:

- PRODUCT LEVELS
- PROCESS TAXONOMY
- DEFINITIONS
- RESTRUCTURING and
- DATA BASE

<u>Product Levels</u>

Everything which deserves the name "system," like a ship, an aircraft or a tank, a car or a TV set can be dissolved into a work breakdown structure (WBS) as shown in Table I.

The product levels shown in Table I are valid for any product whatsoever and provide the first indication of the relevant processes under the heading of "key activity" at each level:

- Assembling (at level I, II and III)
- Making (at level IV)
- Refining and/or forming (at level V), and
- Extracting (at level VI).

If we equate the term of "key activity" with "group of processes," then we have already the first entry into a process taxonomy. The four groups of processes (in reverse order) beginning with Extracting to Refining to Making and finally to Assembling, indicates also the "value-added structure" of every product. Value-added (VA) describes the capital plus labor applied at each level. The output (P) at each level enters the next in the form of material (M). In this hierarchy, we have as input the raw material (RM), six value-added inputs (VA) and one single output (P_1) as shown in figure 1.

Each value-added entry describes a specific process at each particular product level in its most fundamental form and this value-added chain is ubiquitous for all final systems, regardless if we are concerned with military or commercial products and regardless of the multitudes of the possible industrial structures and/or possible

ownership variations, ranging from individual ownership at each level to the complete vertical cartel structure. The Ford Motor company, for example, once owned everything from an ore mine to a rubber plantation in Brazil to the assembly line for its cars. The organizational and ownership structures are sketched (in sample form) in figure 1.

The *organizational structure* can be selected according to the economic facts at a given time. From the eight options, only three are shown. Common to all options is only the step from the level-VI to level-V. From there, the material can directly be delivered to level-I (path P-1) or to any intermediate level (path P-2 and P-3). Economy of scope and economy of scale will drive this organization, and the related decision is frequently referred to as the make-or-buy decision.

The *ownership structure* is the result of the combination of the organizational structure plus the freedom of association as given by the different corporate laws of the nations. Antitrust laws, laws of competition fall into this category. A total of 32 collocated ownership structures are possible, but only 3 are shown. Non collocated structures where, for example, the steel mill (level-V) owns the shipyard (level-I) are not considered:

Process Taxonomy

It should be relatively easy to break down existing systems like air crafts, ships, tanks, missiles and so forth, into the related product levels. However, in order to develop a process taxonomy, we have to differentiate each product at each level, but at least for the levels II through VI the nature of the product, such as

- Structural Products
- Mechanical Products
- Electrical Products
- Electronic Products, and
- Chemical Products.

These five "natures of products" can form together with the previous four "group of processes" a NATURE-PROCESS MATRIX. At each node of this matrix, most specific processes can be entered such as metal forming, metal connecting, metal protecting and so forth. This would provide us with the first step in the development of a process taxonomy.

The second step must be the development of PROCESS PARAMETERS. Some of the most important process parameters might be

- Quality
- Weight, and
- Quantity.

Quality, for example, for mechanical parts or elements (level IV) can be described by the required tolerances or precision needed for the manufacturing process. The quality determines the type of equipment and also the skill of the operator as needed for a specific manufacturing process.

Weight of the elements, components and subsystems (level II, III and IV) determines the lift, or crane capacity as needed to transport them within the factory or between factories.

Quantity, finally, most applicable to material (level V) and chemical products determines the total amount (minimum and maximum) which can be or must be produced with certain existing processes.

• The combination of the process parameters with the nature-process matrix will be the basis for a meaningful process taxonomy.

This process taxonomy, probably consisting of a scant few hundred entries, should be able to represent thousands and thousands of products ... of both commercial and military values.

Definitions

If we are willing (as already mentioned before) to accept a process taxonomy instead of a product taxonomy as the fundamental ordering system of all industrial activities, than we will be able to define our present concerns about the industrial base differently than presently done.

• Instead of Dual-Use we may talk about DUAL PROCESSES and define it as such a process which can be used for commercial and military products without (1) the need for a different knowledge, (2) the need for different tools and (3) with the same degree of tool utilization. In all those cases we can change products "WITHOUT" conversion.

• Instead of the term Conversion, we may talk about PROCESS CHANGES/REALIGNMENT and define it as a situation where the existing processes in a facility are either (1) insufficient for the new product or (2) unnecessary for the new product or (3) will result in an entirely different tool utilization than previously needed.

• The term of reconstitution might be replaced by PROCESS PRESERVATION for all those processes which are UNIQUE for military products and have no practical application for commercial products, for example, the welding of super-heavy, high-tensile metal plates as needed for submarine construction. Processes, recognized and defined as unique for military products, must be either artificially preserved (at high cost) through training exercises for a selected work force or, if possible, replaced through research for new (more robust) dual-use processes. If we do this, the concept of "research without production" may get a new center of interest for research activities and might also strengthen the material research.

Restructuring

Restructuring might be the most difficult problem to address. It is the problem of rebuilding in the future elements of the "military industrial base," whenever needed in a changed political situation and after we have lost the existing capabilities. The crucial questions (according to models built for the Global War Games of the past) where first how long will it take to reconstitute the base and second to what volume of products can the base be reconstituted to in a given time frame.

I suggest consideration of the application of the proposed process concept for the problem of reconstitution. If so, then two base-situations can be imagined:

• first, dual-use (robust) processes exist, but are at a given time exclusively used for commercial purposes by specific individual manufactures of commercial goods, and

• second, the processes are in existence, but distributed among competing companies.

In the first case, we will have to find a way to shift the commercial production to military production and in the second case, we will have to search for a way to re-orient competitors to collaborators - in both cases, assuming sufficient quantitative capabilities exist to possibly satisfy the restructured demand.

Unfortunately, in both cases, the commercial supply will have to be reduced in the interest of military supply and the "guns or butter" trade-off may be realized. With this remark, we are entering the political side of the problem, not subject of the present paper. However, we shall not forget it.

Data Base

Presently, extensive data collection exists (i.e., SIC-code) about "products," but practically no data exists about processes. This however does not mean that this knowledge does not exist. Every technical university is teaching the essence of products AND the processes needed to provide those products. Therefore, it can be assumed that teachers on those institutions will be able as step #1 to identify generically the type of processes in the structural, mechanical, electrical, electronic and chemical field of activity. As step #2, it should be possible to subdivide the generic steps into specific steps according to product parameters of quality, weight and quantity.

Steps 1 and 2 could be performed independently around the purpose of the data base to be developed. But, thereafter, we will have to make value decisions about the specificity of the data collection:

• Shall the new data base serve only for the clarification/objectivisation and foremost; quantification of the technological/ engineering value of the industrial base, or

• Shall the new data base also serve for the clarification/objectivization of the economic-political aspects of the same.

This decision is important in order to MINIMIZE the DATA COLLECTION down to the absolutely necessary effort. Presently, I concern myself only with the engineering aspects.

Step 3 would be the development of a technical questionnaire, tailored to the type of processes, from structural to chemical. This questionnaire would ask for information about the parameters for specific facilities, the present utilization of the process related equipment, the capital/labor ratio for those processes, the years of experience for masters, formen, and apprentices.

However, the questionnaire will not ask any question related to corporate financial aspects.

Step 4, Data collection.

Step 5, Determination of "Military unique" processes.

SUMMARY AND COMMENT

The paper outlined the logic for the proposed shift from a product taxonomy to a process taxonomy. This would change the entire information system about industrial capabilities.

It is clear to me that a process based information system about industrial capabilities is not necessarily simple. But, it

should be simpler than the present product based systems and it should definitely provide more information about the industrial capabilities in peace and war.

It is also clear to me that the task of development, such a new information system needs the team work of many specialists.

However, I am convinced it can be done and the pay-off will be great.

Finally: I invite your comments.

TO PRESERVE AND PROTECT THE DEFENSE INDUSTRIAL BASE

Mark Werfel

ABSTRACT

Current conditions effecting program decisions, authorizations and appropriations create major dilemmas for Defense Industry leaders who are responsible to shareholders for profitability and to their highly skilled employees for employment. Similar dilemmas are facing their Government counterparts. These conditions strain customer relationships, subvert short and long term planning required for goal attainment, interfere with capital investment and may impact their organizational viability. These factors and the associated risk are continuing to deplete the already declining Defense Industrial Base (DIB). The possibility now looms that the DIB will lose its breadth and depth at a time when the nature of our military opponents and the type of warfare to be fought is less certain than ever before. Further, the expected decline of the DIB, the defense technology base and future inability to produce necessary systems questions effective National commitment to defense requirements.

The author presents a new, partnership approach to the DIB, which clarifies responsibilities between the parties and also significantly improves its management.

Key Issues

While the Federal Government is explicitly responsible for national defense, there is an implicit reliance on the private sector for maintaining its bedrock, the DIB; resulting in conflict for Industry leaders who are explicitly responsible to their employer for profitability in the long and in the short term. Within and between each sector, without clear responsibility and accountability, and without clear Government commitment; any long term planning that either does is one-sided and therefore ineffective. Outcomes may include organizational conflict, poor customer relationships, suboptimal and erratic planning and programming, and the possibility that, when needed, portions of the DIB required to support defense requirements will not be available.

Resulting Dysfunction

Industrial costs

It can be argued that the DIB is not managed, but is a fortuitous outcome of the acquisition process. Government financial support for fixed and semi-variable "industrial" costs (e.g., for plant and production equipment) is derived from contracts for delivery of given quantities of weapons systems, which vary annually due to programmatic and budgetary factors. Industrial cost expenditures by industry are very significant, even though their recovery from the Government customer is uncertain. Further, they are not subject to managerial control once committed to, and can only be recovered if the anticipated future work is

Please note that the views expressed in this paper are those of the author and do not necessarily reflect the views of the Department of the Army.

actually received, and at the anticipated annual volume.

Initially, Industry may be required to commit capital, building capacity in anticipation of program/phase authorization and funding, simply to qualify as a potential participant. For the awardee, industrial cost risk then increases, because those costs may not be fully amortized/recovered. Production contract pricing, when performance extends beyond the current year, 1) assumes additional contract work will be awarded in the outyears and 2) overhead costs, including industrial costs, will be absorbed by current and estimated future work. If DOD work levels do not materialize or drop, outyear actual overhead rates may be much higher than anticipated, given they will be allocated across a smaller business base. However, current fixed price contract work can not be repriced. This is today's dilemma when, unexpectedly, production may be eliminated or curtailed.

The vulnerability of plants that are dedicated to one or to a very few customers is particularly and severely high in periods of DOD drawdown/program stretch-out. As a result of DOD funding reductions, weapons systems quantities are being reduced. On previously awarded contract work, while total industrial costs would remain the same, outyear per-unit costs estimated during the original contract negotiations would be greatly lower than unit actual costs. If the resulting unit price increase is not accepted, understood or acknowledged by Government acquisition officials and/or by Congress, it may lead to additional unit quantity reductions or to premature program cancellation. Potential or actual cancellation of a major program that constitutes most or all of a given plant's business base clearly is a key concern for both parties; with many obvious impediments to their objectives. Further, the effect cascades. In a two or three program plant, one program's cancellation will increase the remaining programs' unit costs, and could lead to their cancellation as well. Clearly, the situation is not "win-win."

In addition to industrial costs, recovery of other costs is also uncertain, due to Government contract pricing policies, which frequently change, and often strain the essential principle of fair and reasonable pricing. In the past, fixed price development contract prices reflected less than full anticipated costs; and certain normal business costs, such as for advertising/public relations or IR&D, were unallowable or allowable up to an externally imposed threshold; despite their value to the corporation and/or to national defense.

The need for long term commitment vs. planning

The Government acquisition process, heavily influenced by political and budgetary forces, does not foster the stable business relationship that would benefit both parties. During the past decade, much has been said about the need for long term planning (and, by inference, commitment to plans once accepted). Instead, the situation has remained unstable. For example, the "peace dividend" is a self-fulfilling prophecy, which may, in turn, reduce defense budgets, degrade or constrain the defense industrial base, and reduce its future ability to

replicate a high technology based "Desert Storm" success. From the time of the "Carlucci principles" to today's "Total Quality Management and Re-Engineering," the desirability of long term planning, improving processes and eliminating unneeded or unwarranted activities directed to reduce significant variation in their outputs have been championed, but not achieved. Instead, the acquisition process state and such concomitant results as the substantial price/cost variation described above is inconsistent with and interferes with customer relationships (note, the customer may mean the program manager, Defense leadership, the Congress or the public).

National priorities are shifting and the DIB must respond. The military threat is being reduced, but its nature is changing. Our focus will shift to such issues as the industrial infrastructure and the environment. While large active military forces and weapons inventories may no longer be afforded or required, the DIB structure must correlate with any expected military threat, from a Desert Storm to a Somalia; and do so in such terms as technology/weapons mix, abbreviated leadtimes and logistics.

Traditionally, the DIB received less attention because defense products were less complex, and many could be manufactured by commercial plants, with substantial leadtime afforded by our distance from potential enemies. This is not true today. Sophisticated weapons systems drive special purpose plant and equipment (and the "industrial costs" discussed before); which render Defense plants unlikely or unable to convert to commercial use. Further, once allowed to deteriorate, not only will the DIB be less flexible for various conflict scenarios, require more time to ramp up but, in certain situations, may be more costly on a net basis due to shut down/start up costs. Similarly, skilled employees and production related experience may be unavailable if, as currently planned, weapons system programs do not progress past the full scale development phase. Due to the increase in contractor financial risk apparent in the drawdown, industry may not participate or may demand much higher profit rates than previously.

IMIP, an earlier approach

The DOD's Industrial Modernization Incentives Program (IMIP) was intended to address the industrial cost problem in the early 1980s. IMIP had a two pronged approach:

1) to improve the return on investment, bringing it up to market levels, so that a defense firm would not seek alternative investment opportunities for its capital (and also be willing to invest in more efficient equipment, increasing profit while reducing cost based contract pricing)

2) to "guarantee" amortization of facilities cost over a negotiated, program based production quantity. If less than the number of units were ordered, the Government would recognize a pro rata share of the shortfall between the net asset value and net proceeds of the equipment's sale price.

IMIP's concept was and is theoretically sound; offering high potential benefit to both contracting parties. However, it was never fully developed. The budgetary increases of the Reagan era defense buildup, and the competing goals of CICA (the Competition In Contracting Act) overcame the driving force for detailed implementation. As a result, IMIP has not achieved its potential and the DIB issue persists today. Certain initial IMIP policies were considered for implementation, but not adopted, that would have mitigated the current scenario.

Commercial/Defense Industrial Base: Distinction or Confusion?

By clearly distinguishing between the Defense and the Commercial industrial base, DOD would accept responsibility for the former, and its inability to control or to interfere with the latter. Appropriate Government management action could then be identified (steps to be taken or precluded for each), eliminating the longstanding ambivalence that results when DOD attempts to achieve many competing goals. Examples of that ambivalence abound:

a. flowdown of Government contract clauses, cost accounting regulations and oversight to a commercial base that offers some products that are better and cheaper, but can not or will not accept Government controls.

b. obtaining data rights so that the Government can compete future work, and thereby obtain lower prices, while Industry will not produce intellectual property that they are not properly compensated for, from their perspective. The firm expending the effort may not only be denied a competitive advantage, but may also see their invention transferred to their competitors.

c. CICA/competition motivated dual sourcing, accommodated during the Reagan defense buildup, produced adverse results in today's drawdown. Today, the business base for many systems do not economically support two suppliers. Defense firms or business units that merge have been allowed to retain the cost savings resulting, implying a cost increase due to competition when instead, sole source would have been economically, but not politically, correct. While the Federal Trade Commission has objected to defense contractor mergers if a sole source situation would result, there is no realistic alternative. If dual sources remain, they are likely to be weaker from both a financial and technology/production capability standpoint. Accordingly, over the long term, the intended CICA based savings to DOD may not have been achieved.

Defense plants will not be available if they convert to non-military markets, or worse, if they fail. Nor should they be expected to be available without appropriate financial support. The need for a capable defense industrial base is only tacitly accepted, but is not actively supported. The essential element of this problem, on the macro level, is that DOD does not explicitly recognize its financial responsibility for the industrial costs that benefit it. On the micro level, there is no "contract" for a contractor's facility, which would specifically recognize these industrial costs. Instead, it is a contract by-product;

without responsibility focus. Seldom, if ever, are industrial costs meaningfully discussed at contract negotiations with acquisition or contract management organizations; even in the most obvious case, when a single program comprises a plant's entire business base.

Instead, if the DOD/Commercial industrial base distinction is realistically made, DOD can manage the former more effectively and utilize the latter in a way that it has not before. The defense base would then be a Government responsibility, and its relationship with industrial firms would become more of a partnership, reducing acrimony and optimizing shared goal attainment. The commercial base, while it would recognize that the Government is a major customer, would not be constrained in delivering products that will compete and win in what is becoming more of a world-wide marketplace than ever before. In fact, we should recognize that not only would commercial firms generate better and less costly products, but also the income which can be taxed to pay for the defense base.

DOD's DIB implementation.

Organizing accordingly

Once DOD accepts that responsibility, it should organize accordingly, by industrial sector (e.g., satellites, shipbuilding, military vehicles, or munitions). Service acquisition organizations are already organized by sector (e.g., for aircraft, the USAF's Aeronautical Systems Division, Naval Air Systems Command and Army Aviation Systems Command); but additional mechanisms may be required for a total DOD perspective of each sector. Once accomplished, each DOD sector would consolidate existing Service time phased requirements for systems: for their development, production, and include surge/mobilization considerations.

The sector level approach

The next step would be to evaluate the existing dedicated DIB that supports each sector, to include both prime and subcontractors, and which may overlap with other sectors to some extent. This is not overly burdensome, as only major plants would be involved, most which have resident contract management organizations already. These plants have a predominant Government business base, comprised of a single or of many programs. Once those plants are identified, a review of each plant would be in order (for example, "Should Cost" reviews identify those plants that are not operating efficiently). By matching each sector's requirement with the DIB supporting it, excess capacity would be identified as well as the basis for selecting firms most deserving of continued support. These decisions would not be entirely subjective, but would include quantitative factors summarized at the OSD level. Firms not selected would then be forced to transition to the commercial industrial base, during which they would be allowed to complete their current contract work or to sell it to the DIB survivors without FTC challenge. While smaller, the resulting DIB would be much stronger, and the Commercial Industrial Base would similarly benefit.

DIB contracting

Many other improvements would result. DIB prime contractor activities would more explicitly recognize their systems integrator role, really a partnership, enabling program managers to perform many Government responsibilities from a broader and deeper perspective. Industrial costs, costs for such current tasks as long term planning or intellectual property, and for such new tasks as identifying and evaluating commercial products which could be utilized in weapons systems (e.g., for "dual use" initiatives) are expended for the mutual benefit of both partners. Rather than charge "partnership" costs indirectly, as currently, they would be charged direct to a new, separate contracting mechanism, collecting costs for each DIB plant.

For example, industrial costs and many of the traditional systems integrator activities and responsibilities would be reflected in a separate contract for each plant; with concomitant improvement to planning and programming activities. The costs would be the same as before (or lower, because they would be directly managed by accountable individuals in Government and Industry; and logically, one would assume improved information and control results in efficiency and effectiveness), but charged differently:

An appropriate contract type could be cost plus award fee, with the expectation that the Government fee determining official (FDO) would probably be at the PEO or acquisition executive level. The FDO would have a sector wide and/or DIB wide perspective, and would be briefed by a high level Industry counterpart, so the expectation would be that plants would be appropriately modernized and technology would be pursued to support stated Government objectives, and appropriately rewarded.

Given plant costs would be recognized separately, weapons system unit production costing would be based on the incremental quantity desired, removing the negative programmatic aspects cited in the beginning of this article. Because of the partnership arrangement, the industry partner would expect defined future production work, and be allowed access to now denied acquisition sensitive information, facilitating joint planning. Depending on the situation, costs at issue could be charged to the plant contract or to the production contract, as agreed to by the parties.

In the commercial industrial base, Government controls and contractual language will no longer be applicable. Interdivisional cost transfers from a firm's commercial units to DIB units would be accepted by the Government as certified by the industrial partner's commercial accounting firm, and cost accounting standards would not flow the other way. Currently, commercial accounting firms certify financial information, subject to GAAP standards and Securities and Exchange Commission regulation. That information is accepted by the investment community, and could be accepted by Government acquisition organizations as well. Given some extraordinary issue, DCAA could be allowed entry to commercial base unit accounting records as agreed to on an

exception basis at a high Government/Industry level.

Summary

It is clear that current conditions demand this new approach be pursued. When it is, the positive, partnership approach espoused by many for several years will be attained, and will persist. Once begun, the process action teams and product improvements underway will become much more effective, because their scope would be widened within targeted DIB sectors. This initiative should be combined with a similar review of the technology base. Lastly, with relief from burdensome Government regulations, the commercial industrial base could deliver lower cost and higher quality products to all potential customers, due to greater economies of scale resulting from access to Government/Defense markets.

Please note that the views expressed in this paper are those of the author and do not necessarily reflect the views of the Department of the Army.

ENGINEERING AND MANUFACTURING MANAGEMENT

THE USE OF ORDINAL SCALES IN DEFENSE SYSTEMS ENGINEERING

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ABSTRACT

Ordinal scales are often used in performing risk and System Maturity Matrix (SMM) assessments as part of the system engineering process in defense programs. However, ordinal scales are frequently used incorrectly in these assessments. The results obtained can be meaningless, thus undermining the effectiveness of the program's system engineering process. Limitations of using ordinal scales for risk and SMM assessments are explored in this paper. Examples are presented from published defense program risk analysis and SMM methodologies illustrating common errors, along with recommendations to correct these errors.

INTRODUCTION

Aggressive risk management by both government and industry is generally essential for program success. Program decisions and resource commitments must be based on plans for, and progress in, controlling risk.

Risk analysis (and risk assessment), part of risk management, and System Maturity Matrix (SMM) techniques are often used as part of the overall systems engineering process. Risk areas called out in Department of Defense Directive (DoDD) 5000.1 to be assessed at milestone decision points include: threat, technology, design and engineering, support, manufacturing, cost, and schedule [1]. The SMM is a tool to track technical progress and risk. It links user specified requirements to specific test results during system development. Actual progress towards requirement verification is readily apparent through the use of metrics [2]. In risk management and SMM, the program manager is given broad latitude how to implement each process. (I do not discuss the implementation processes here due to space limitations.)

Ordinal assessment scales are often used to compute the level of risk or measure the level of technical progress in DoD programs. Here, the resulting numerical value associated with risk or technical progress is dependent upon the place (e.g., first, second, etc.) it occupies in the ordered sequence. The numerical value of ordinal data indicates its relative position or standing [3].

Although ordinal assessment scales can be utilized in risk analysis and SMM techniques, the scales may be inherently flawed, and the resulting numerical output may be meaningless. For example, the program manager may wish to fund one or more potential risk reduction options, but the

prioritized list he evaluates may have very little value if improperly derived.

I examine in this paper some common errors associated with using ordinal scales in risk analysis and SMM, and offer possible solutions to these problems. These errors are not simply drawn from theoretical considerations, but from actual experience obtained on several large-scale Department of Defense programs over the past decade. Moreover, many of the ordinal scale problems I will discuss are applicable to a broad range of systems engineering applications beyond risk analysis and SMM.

I provide in the remainder of this paper a definition of risk, then present and discuss limitations associated with using ordinal scales in risk analysis and SMM, some general issues that affect the ability to perform these assessments, and briefly discuss two published risk management examples that incorrectly use ordinal scales.

THE MATHEMATICAL REPRESENTATION OF RISK

Risk is defined in the Defense Systems Management College (DSMC) Systems Engineering Management Guide as the: "combined effect (product) of the likelihood of the occurrence and a measured or assessed consequence given that occurrence." [4] The likelihood of occurrence refers to the probability of the event taking place. Similarly, the DSMC Risk Management Concepts and Guidance document defines risk as the product of "the probability of an undesirable event occurring and the significance of the consequence of the occurrence." [5]

The word "risk" is often used incorrectly to represent only the probability term. The correct usage is risk as the product of the probability and consequence terms. The word uncertainty is appropriate for ordinal scales, which clearly do not represent probabilities. (I use the term "risk (uncertainty)" in the rest of this paper to indicate instances of uncertainty where the term "risk" is generally incorrectly used.)

Ordinal assessment scales (discussed in the next section) can be used, so long as it is recognized their values are not probabilities and they cannot be used to calculate risk (as defined above).

Ordinal assessment scales may express the level of uncertainty for the item being evaluated. They are potentially well suited for the DoDD 5000.1 threat, technology, design and engineering, manufacturing, and support risk assessment categories, plus other potential categories deemed necessary by the program manager (e.g., hardware/software integration).

Quantitative cost and schedule risk assessment methodologies can ideally estimate risk since probabilities of occurrence result from the simulation process and the consequence term directly represents either cost (dollars) or schedule (time). (Ordinal scales are sometimes misused in establishing characteristics of cost or schedule probability distributions at the Work Breakdown Structure level. However, I do not discuss this issue here due to space limitations.)

Given this introduction, it is beneficial to examine appropriate definitions of uncertainty applicable to program risk categories.

There are typically five classes of uncertainty: (1) certainty; (2) probability distributions of known form embedded in

known models, covering known possible states; (3) probability distributions of unknown form embedded in known models; (4) uncertain models (strong uncertainties); and (5) chaos [6]. The military system development process is typically representative of states (3) and (4). Imperfect information typically exists for a given set of program risk category (e.g., threat) attributes; hence states (1) and (2) are unlikely. Conversely, some knowledge of possible risk category trends typically exists; hence state (5) is unlikely.

Ordinal assessment scales, which do not require assumptions about probability distributions, are compatible with states (4) and possibly (3) are potentially well suited for risk categories such as threat, technology, design and engineering, manufacturing, and support. This is not to say that ordinal scales are without defect or that mathematical operations can be performed on the results (as discussed in the next section).

However, the basis for quantitative analytic or stochastic risk assessments, including cost and schedule, is state (2), where probability distributions of known form are embedded in known models, covering known possible states. A match is unlikely to occur between the true program probability distributions and those used in the risk analysis procedure. Thus, even the results of quantitative risk assessments are likely to be somewhat unreliable.

SOME LIMITATIONS OF USING ORDINAL SCALES

Some Inherent Limitations of Ordinal Scales

A number of caveats exist for using ordinal scales in the risk analysis process. First, ordinal scales values represent rank orderings. For example, the fifth scale level (value of 5) is greater than the fourth scale level (value of 4). Second, ordinal scale value are generally not absolute. For example, the lowest values does not necessarily represent a cardinal "0" value or any other value. There is no valid rationale to assign decimal values to uncalibrated ordinal scale levels, since the scale levels are ordinal, not cardinal, in nature. In addition, providing decimal scale level scores (e.g., 0.2) suggests a degree of accuracy that is unwarranted and invites the user to perform mathematical operations which will yield erroneous results (as discussed below). Third, ordinal scales generally have arbitrary intervals between scale levels. For example, the difference between levels 5 and 4 is likely not the same as between levels 4 and 3. Providing linear, logarithmic, exponential, or other transformations for uncalibrated ordinal scale levels will yield meaningless results. Fourth, ordinal scales are monotonic and positive in nature--meaning that the uncertainty associated with level 5 is greater than level 4, which is greater than level 3, etc. However, as mentioned in the third item above, the degree to which level 5 is greater than level 4 is generally unknown.

Hence, while the scale level assigned to a given item (e.g., subsystem) may be correct when evaluated for a given risk or SMM category, the associated numerical value is generally not meaningful beyond an ordering sense unless the scales are calibrated. For example, the best that can be said of an score of 5 is that it is greater than a score of 2. It is not, however, 2.5 times greater than a score of 2, or generally any other known factor, but simply greater than 2.

With uncalibrated scales, it is not possible to perform any mathematical operations with any degree of confidence unless the ordering

of the sums or products is maintained at all levels. However, even then the resulting quantitative values will only represent rank ordering between items. For example, if two ordinal scales are used and item 1 receives scores of 5 and 4 for the two scales and item 2 receives scores of 4 and 3 for the same two scales, the best that can generally be said is that item 1 has a higher level of uncertainty than item 2.

Values Are Not Probabilities

Ordinal scale values are not probabilities, which are also cardinal values. Hence, any mathematical manipulation between categories (e.g., technology and manufacturing) or subcategories (e.g., manufacturing process difficulty and production equipment status within manufacturing) is not statistically rigorous since the original values are not probabilities.

Ordinal scale values are not probabilities simply because the developer of the scale uses decimal scale value scores and/or declares the values to be probabilities!

Given multiple ordinal scales, the analyst or program manager is often tempted to roll-up the scores mathematically into a single value. I have examined a variety of normalization schemes and averaging techniques--none of them yield meaningful results. I have also observed a variety of other mathematical operations performed on uncalibrated ordinal scores, ranging from simple algebraic manipulation to representing coefficients of partial derivatives. Again, the results are meaningless.

Techniques exist that may be used to calibrate ordinal scales, such as the Analytical Hierarchy Process (AHP) [7]. (The calibration of scale levels within a single ordinal scale can be viewed as vertical calibration. Calibration (weighting) between scales can be viewed as horizontal calibration.) While this may provide a relative calibration within a scale for different levels, or between scales, it will not absolutely calibrate any given scale level or weighting between scales. For example, if the fifth technology scale level has a calibrated score of 4.6 and the fourth scale level has a calibrated score of 2.3, then the fifth scale level is 2.0 times greater than the third scale level. However, the calibrated scores are not probabilities, and the absolute magnitude of any scale level generally remains unknown. For example, the lowest scale level does not represent zero probability or uncertainty in almost any instance.

In addition, it is not advisable to perform mathematical operations on scales with relative calibration because the meaning of the results may be difficult to interpret. For example, if three categories are used; such as technology, design and engineering, and manufacturing; and their respective calibrated scale scores for a particular item are 6.0, 1.5, and 0.5, it is generally of greater interest to note each score, than the sum, average, or other combination of the three scores which tends to mask the relatively high technology score.

In general, it is recommended that raw ordinal scores be used in the program's risk management and SMM tracking process. When a single score is needed per category, then the highest of the subcategory scores should be used. Although this represents a conservative approach, it prevents potentially noteworthy issues from being masked and overlooked.

Inconsistent Ordinal Scale Definitions

Lengthy ordinal scale level definitions should be avoided since they provide the possibility of multiple attributes per level or ambiguities for a given level or between levels. For example, if three separate attributes must be met to move from a score of 3 to 2, how should the analyst interpret meeting one of the three criteria or two of the three criteria, but not all three? While the conservative approach is to require all criteria be met to achieve the next lowest score (in this case going from a 3 to 2), it may well be better to focus the ordinal scale definition to a single attribute, and provide clarifying information in a supplementary write-up.

Similarly, as the number of scale definition attributes increases, so does the possibility of having ambiguities for a given scale level or between two or three adjacent scale levels. For example, if three attributes exist for scale levels 4 and 5 it may be possible that one or more of the attributes for scale level 4 may actually imply a higher level of uncertainty than one or more attributes for scale level 5, thus violating the underlying assumption that the scale is monotonic and positive in nature.

A definition with generally less than 10 words, or certainly less than 15 words, is likely sufficient to convey the intent of the scale level without creating a multi-attribute or ambiguous definition. Additional information to convey nuances and clarify the scale level definitions can be provided separately. One or two word scale definitions should also be avoided since they are too subjective even if supplementary material is available.

How Many Ordinal Scale Levels Are Appropriate?

Three scale levels are generally too few, while 10 or more levels are generally too many. In the former case there is generally too little granularity, while in the latter case too much. The tendency when only three levels are used is to automatically assume they represent high, medium, and low uncertainty, which may not necessarily be the case. When a large number of scale intervals are used the possibility exists that ambiguities between two or three adjacent scale level definitions may occur. In addition, a large number of scale levels are generally inappropriate unless a well defined, repeatable process exists that is being evaluated.

Some Ordinal Scale Characteristics

Many ordinal risk (uncertainty) and SMM scales are time-event based, and their values represent a state of maturity. That is, higher scores generally represent items or programs in early stages of development, while lower scores generally represent more mature events, including production programs or deployed items. (Of course, the scale ordering or associated numbering can be reversed if desired.) This is generally the case for ordinal technology, design and engineering, and manufacturing scales. It may be the case for ordinal support scales. It may also be implied in ordinal threat, cost, and schedule scales. An inherent, and generally valid, assumption in using such ordinal scales is that the item being evaluated generally follows the requisite time-varying maturity, and not an arbitrary order (even though some fluctuations may occur).

Possible Correlation Between Scale Sub-Categories and Categories

The relationship between ordinal subcategory scales for a given category (e.g., manufacturing process difficulty and

production equipment status) or between categories (e.g., technology and design and engineering) may not be uncorrelated. This is often true at the highest and lowest scale levels, which imply for example, scientific research and operational systems, respectively. If the subcategories or categories are correlated with each other, then they are not statistically independent. Statistical independence may be a necessary assumption for performing some mathematical operations on ordinal scale values--particularly if the erroneous assumption is made that scale values are probabilities.

However, even if correlation coefficient(s) between scales can be identified, they cannot be used in any meaningful way to adjust the numerical results because of the ordinal, non-probability limitations present.

Ordinal Scale Titles

Calling ordinal scales "confidence" scales as done in some instances is misleading--the same limitations apply to the scales regardless of their title. In addition, there is no relationship between these scales and the statistical confidence interval, as discussed next.

Absence of Confidence Intervals

No confidence intervals around a given risk (uncertainty) or SMM score can be generated because of the ordinal and non-probability nature of the scales.

Incompleteness of Scale Categories

The ordinal scale sub-categories may not provide an extensive representation of the uncertainty contributors for a given risk or SMM category. For example, a single technology scale may represent a component of technology risk (uncertainty), but it is not likely an all-inclusive descriptor of this risk (uncertainty). Implementing additional sub-categories will may increase the difficulty of interpreting and rolling-up the resulting scores because of the ordinal nature of this methodology than if a cardinal methodology (e.g., probability-based) is used.

Risk Categories

The DoDD 5000.1 risk categories should be viewed as the minimum number of risk categories to be evaluated, although the threat category may diminish in importance in the 1990s for some defense systems (e.g., strategic). (All or a subset of these categories should be used in the SMM for tracking maturity.) The technology and design and engineering risk categories may include both hardware and software subcategories. Other risk categories can be developed and used at the discretion of the program manager. For example, risk assessments for hardware/software integration may be warranted in some cases.

Some risk categories may be misnamed, and actually represent another risk category. For example, software manufacturing should be designated as software design and engineering. Other risk categories may be inappropriate or inherently ambiguous and should be eliminated. This includes categories such as dependence/correlation (which affects the relationship between categories), requirements (perhaps too broad), complexity (too vague), reliability (better treated as a technology or design and engineering consideration), alternate item availability (better evaluated by rating the alternate item(s)), and criticality to mission (actually related to the consequence term).

The number of subcategories per category can have the undesirable impact of weighting the importance of a given category. For example, if threat risk is represented by 7 subcategories (with one scale per subcategory) while technology risk is represented by only a single scale, no greater level of importance should be placed on threat risk than technology risk (all else held constant). The true number of subcategories per category may be masked in cases where the DoDD 5000.1 risk categories are not clearly delineated. For example, in one set of published ordinal risk (uncertainty) scales, statistical process control, producibility, and manufacturing precision are listed as risk categories, yet all are related to the manufacturing risk category. In this set of scales, technology (Technology Status), design and engineering (Required Technical Advancement), cost (Cost), and schedule (Schedule) were represented by a single scale. Thus, in this case the analyst may erroneously assume that manufacturing is the dominant risk category, when this is not necessarily true.

If multiple subcategories exist, particularly if derived from uncalibrated ordinal scales, a single score, generally the highest of the subcategory scores, should be reported at the summary level to avoid the appearance of importance being related to the number of subcategories per risk category.

Biased results will still likely exist when multiple subcategories are present even if vertically calibrated ordinal scales are used. This will be the case unless a horizontal calibration is performed between subcategories per risk category and between risk categories by a suitable technique (e.g., AHP, but note the potential limitations discussed above).

Consequence of Occurrence Term

While the probability risk term is bounded by 0 to 1, the consequence risk term can range from zero to infinity--a much greater range. When ordinal consequence scales are used the resulting compression versus cardinal consequence may easily reach several orders of magnitude (e.g., a cardinal factor of 500 versus 5 ordinal levels) making interpretation by decision makers difficult.

Given an ordinal or cardinal consequence score, there is an inherent danger of the analyst or program manager multiplying it by an ordinal uncertainty value in an attempt to obtain risk. An ordinal or cardinal consequence term cannot be multiplied with a calibrated or uncalibrated ordinal uncertainty scale score to obtain risk. This is because risk requires the uncertainty term to be a probability, and, strictly speaking, the consequence term to be a cardinal number. Consequently, even if a calibrated ordinal uncertainty and consequence scales are used, the resulting product value is not risk.

As in the uncertainty dimension, a single ordinal scale or descriptor may not be sufficient in most cases to capture the impact of consequence of occurrence. For example, while dollars and time are often suitable consequence descriptors for cost and schedule risk, no single consequence scale or simple descriptor is likely possible for other risk categories, including, threat, technology, design and engineering, manufacturing, and support. Multiple descriptors or consequence scales may be needed to properly assess the impact on the overall vehicle mission.

Some candidate consequence scales for aircraft, launch vehicles, missiles, and spacecraft, might include: anomalous item severity (the impact the anomaly has on the

specific hardware item), functional effectivity (the impact the anomaly has on the performance capability of various levels of vehicle assembly), mission effectivity (the effect the anomaly has on the overall system), and mission impact severity (the impact the anomaly has on the vehicle's ability to fulfill its mission objectives).

TWO EXAMPLES OF INAPPROPRIATE USE OF ORDINAL SCALES

I will briefly summarize some errors pertaining to the use of ordinal scales for risk management found in two DSMC publications.

The first case involves software risk analysis scales developed by Air Force Systems Command [8], which appeared in the DSMC Risk Management Concepts and Guidance [9]. The ordinal scales had three levels (too few), the levels were inappropriately given decimal values (0.0-0.3, 0.4-0.5, 0.6-1.0), and the levels were incorrectly termed probabilities. Many of the scale definitions were too short (e.g., verified projections), subjective (e.g., little or none), or contained multiple attributes (e.g., documented, validated, in place).

The second case involves risk analysis scales which appeared in the second edition of the DSMC Systems Engineering Management Guide [10]. (This material was deleted in the subsequent edition.) The ordinal scale levels were inappropriately given decimal values (0.1, 0.3, 0.5, 0.7, 0.9) and the levels were incorrectly treated as probabilities in some cases. Many of the scale definitions were too short (e.g., existing), subjective (e.g., significant increase), or contained multiple attributes (e.g., technology available, complex design). Invalid mathematical equations were given to derive an overall probability of failure, consequence of failure, and risk factor. (The underlying ordinal numbers cannot be mathematically manipulated.) The complexity factor "probability" category may actually represent design and engineering. The dependency factor "probability" category is inappropriate (affects the relationship between categories). Finally, portions of the cost factor scale represent risk rather than consequence (e.g., cost estimates increased by 5 to 20 percent).

CONCLUSIONS

Risk analysis and SMM are potentially important defense program system engineering tools. Ordinal scales are often used to quantify the level of risk or maturity present in these assessments. However, a broad range of errors may result due to assumptions associated with the nature of the ordinal scales. These errors can lead to meaningless results which may adversely affect the integrity of the program's systems engineering process.

Common errors associated with the use of ordinal scales include assumptions that the resulting numbers: are cardinal, represent probabilities (for the non-consequence term), and can be mathematically manipulated.

Values obtained from ordinal scales are not cardinal, and the absolute magnitude of the scale levels may remain unknown even after calibration. In addition, true risk values cannot be generated from ordinal scales, since risk is the product of likelihood of occurrence (probability) and consequence of occurrence terms. Finally, results obtained from mathematical operations are generally inaccurate for uncalibrated ordinal scales, and may not be meaningful even when the scales are calibrated.

Ordinal scales may also contain substantial flaws, including: inconsistent scale level definitions, an inappropriate number of levels, correlation between different categories, and the incomplete nature of scales representing a given risk category.

Finally, some potential problems associated with risk categories and the consequence of occurrence term often exist. In the risk case the tendency is to include inappropriate categories, or too many subcategories per risk category. In the consequence case the inclination is to use only a single consequence of occurrence category when more than one may be desirable, if not necessary.

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DISCLAIMER

This paper is based upon research conducted by the author during 1985-1995. The views expressed are those of the author and not necessarily those of the United States government or any of its agencies.

POLLUTION PREVENTION IN THE ACQUISITION PROCESS

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ABSTRACT

Recent environmental legislation passed by the U.S. Congress is forcing industry to address pollution prevention during the production process. Companies selling to the Department of Defense are not exempt from these requirements. This paper examines the acquisition process from Phase 0 (Concept Exploration & Definition) to Phase IV (Operations & Support) in an effort to determine where in the acquisition process pollution prevention activities can be most cost-effective. A methodology is then presented which allows for the evaluation of products from an environmental approach. This approach is known as Life Cycle Assessment (LCA) and provides an estimate of the total environmental burden of a weapon system. An LCA evaluates the environmental releases and impacts of a product/process/activity by tracking its development from raw materials to through production and ultimately to demilitarization or disposal.

INTRODUCTION

The Congress of the United States enacted Public Law 101-508 on November 5, 1990. This law is also known as the Pollution Prevention Act of 1990. The intent of this law is to force all industry to reduce or prevent pollution at the source, i.e., during the production process. For those companies involved in Department of Defense activities, this is during the weapon system acquisition process. The acquisition process includes the development, production, operation, and final disposition of all weapon systems procured by the Department of Defense (DoD). Also included in this concept are the raw materials used in the production and maintenance of weapon systems. By addressing the issue of pollution prevention early in the acquisition cycle, cost-effective changes can be made to a system to allow it to comply with all environmental laws. This will have the effect of reducing the potential for costly liability settlements by the federal government as well as protecting the environment.

In order to be most effective, an environmental philosophy must be implanted in the acquisition process beginning with Phase 0, Concept Exploration. During this phase, the types of considerations should include the potential environmental impacts of the various options being considered. It is during this phase that the most cost-effective pollution prevention design decisions can be made. In Phase I, Demonstration & Validation, system performance and environmental impact trade-offs must be made. This is the final phase in which the window of opportunity for cost-effective pollution prevention solutions remains completely open. Beginning with Phase II, Engineering & Manufacturing Development, opportunities for pollution prevention begin decreasing because the weapon system design is frozen and the issues shift to those of control of harmful substances and compliance with applicable laws.

DISCUSSION

Pollution prevention is quickly becoming more than a desirable goal. It is approaching the status of a necessity. Clean-up costs are skyrocketing. Hazardous waste disposal and liability costs have increased tenfold over the past five years. Landfill space has dwindled 80% over the past decade (1). Even with total compliance with all regulatory laws and policies, the lack of physical space for disposition of wastes cannot be ignored. Siting for new landfills or hazardous waste facilities has become extremely contentious. Not-in-my-backyard (NIMBY) has become the rallying cry of those individuals and groups opposing new landfills or other types of waste facility. Examples of this situation abound. A recent article in The Wall Street Journal describes the situation in San Diego,

California, where a group of homeowners is suing San Diego County for $20 million because the county plans to expand an existing landfill, a landfill that existed before most of the homeowners moved into the area. What makes this case somewhat unique is that the landfill is not in a poor or minority neighborhood. It is located in one of the county's most affluent areas (2). Similar situations will almost certainly occur in many other parts of the country. To minimize these, systems must be designed that avoid or reduce disposal requirements.

Most current environmental programs deal with the end of the acquisition pipe. Clean-up and compliance policies and programs fall into this situation. To a certain extent, conservation programs do also. This is the least desirable and most costly option to addressing environmental pollution. Pollution prevention, on the other hand, deals with environmental protection at the other end of the acquisition pipeline - during Phase 0 (Concept Exploration) and Phase I (Demonstration/ Validation). Once a program has progressed into Phase II (Engineering and Manufacturing Development), emphasis necessarily shifts to pollution control, compliance with appropriate laws, and ultimately, clean-up and disposal. Environmental considerations during each stage of the acquisition cycle are shown in Figure 1.

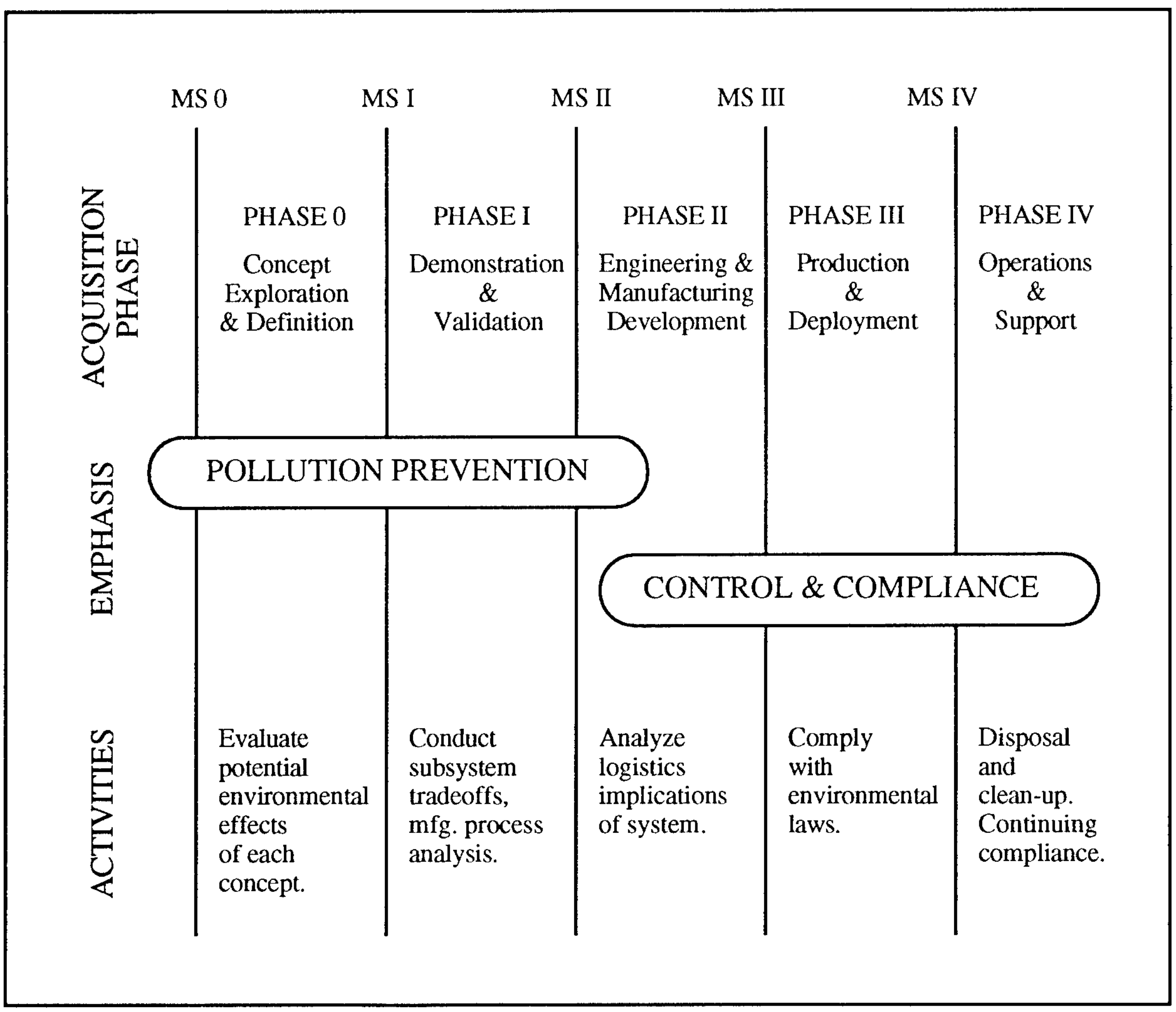

Figure 1. Environmental Activities in the Acquisition Cycle

An ounce of prevention is worth a pound of cure. Everybody has heard this old Ben Franklin adage many times. If an ounce of prevention is in fact worth a pound of cure, that's a 16 to 1 benefit/cost ratio. Is this platitude applicable in today's world when addressing problems such as pollution prevention? Examples from a number of companies have shown that this is possible. Forty documented case studies have shown that pollution prevention is not only good in terms of protecting the environment, but also in terms of dollars and cents (3). The firms involved in the case studies were grouped by Standard Industrial Classification (SIC) codes and encompassed agriculture, mining, food products, textiles, furniture, paper and printing, chemicals, electronic and electrical equipment, and service industries. The results are impressive. By adopting pollution prevention strategies, the firms achieved the following:

- 13 firms improved productivity,
- 26 firms reduced raw material usage,
- 13 firms improved energy costs,
- 17 firms reduced pollution control costs,
- 7 firms improved product quality.

While not all of the SIC codes covered in the case studies are applicable to the defense industry, certainly those in the SICs for chemicals, electronic and electrical equipment, and service industries are appropriate.

Can these cost savings, already recognized by private sector firms, be realized in the systems acquired by DoD? The federal government and the Department of Defense apparently feel that the answer to this question is "Yes". DoD is getting very serious about pollution prevention. How serious are they? Serious enough to create a program and position at the deputy under secretary of defense level. The secretary of defense has created the DoD Environmental Security Program and placed the responsibility for this program under the Office of the Deputy Under Secretary of Defense (Environmental Security) (ODUSD(ES)). The mission of this office is to integrate DoD environmental concerns and policies. To this end, DoD has developed a number of directives and instructions dealing with pollution prevention, including DODD 4210.15, Hazardous Material Pollution Prevention, and a revised DoD 5000 series dealing with systems acquisition. DoD Instruction 5000.2, Defense Acquisition Management Policies and Procedures, dated February 23, 1991 typifies this increased environmental emphasis. In this revised Instruction, none of the acquisition milestones can be successfully completed without analysis of the potential environmental consequences of the program and development/identification of appropriate mitigation measures. DoD Instruction 5000.2 further requires that the Integrated Program Summary necessary for Milestones I, II, III, and IV, contain in Appendix E the environmental analysis. Procedures for conducting this analysis are contained in Part 6, Section I (4).

The problem then becomes one of developing a systems acquisition methodology that can incorporate pollution prevention concepts into it. Fortunately, the basis for such a methodology already exists and is well established in the acquisition process - life cycle costing. Life cycle costing has been used for a long time in the acquisition process to calculate "cradle-to-grave" costs associated with a weapon system. This concept is still valid, except that "cradle-to-grave" needs to be expanded to include what happens when the hardware associated with a weapons system reaches the "grave". Will it be around for hundreds or thousands of years after it is disposed of? Will its residues seep in to local ground water supplies? Will the cost of ownership continue far beyond its demise?

Life Cycle Assessment (LCA) is the name given to the current approach in evaluating products from an environmental approach - the environmental burden of a weapon system. An LCA evaluates the environmental releases and impacts of a product/process/activity by tracking its development from raw materials through production, and ultimately to disposal. LCAs are not a new phenomenon. They have been used for approximately the past twenty years. Most of the studies have been funded and conducted by private firms and are not

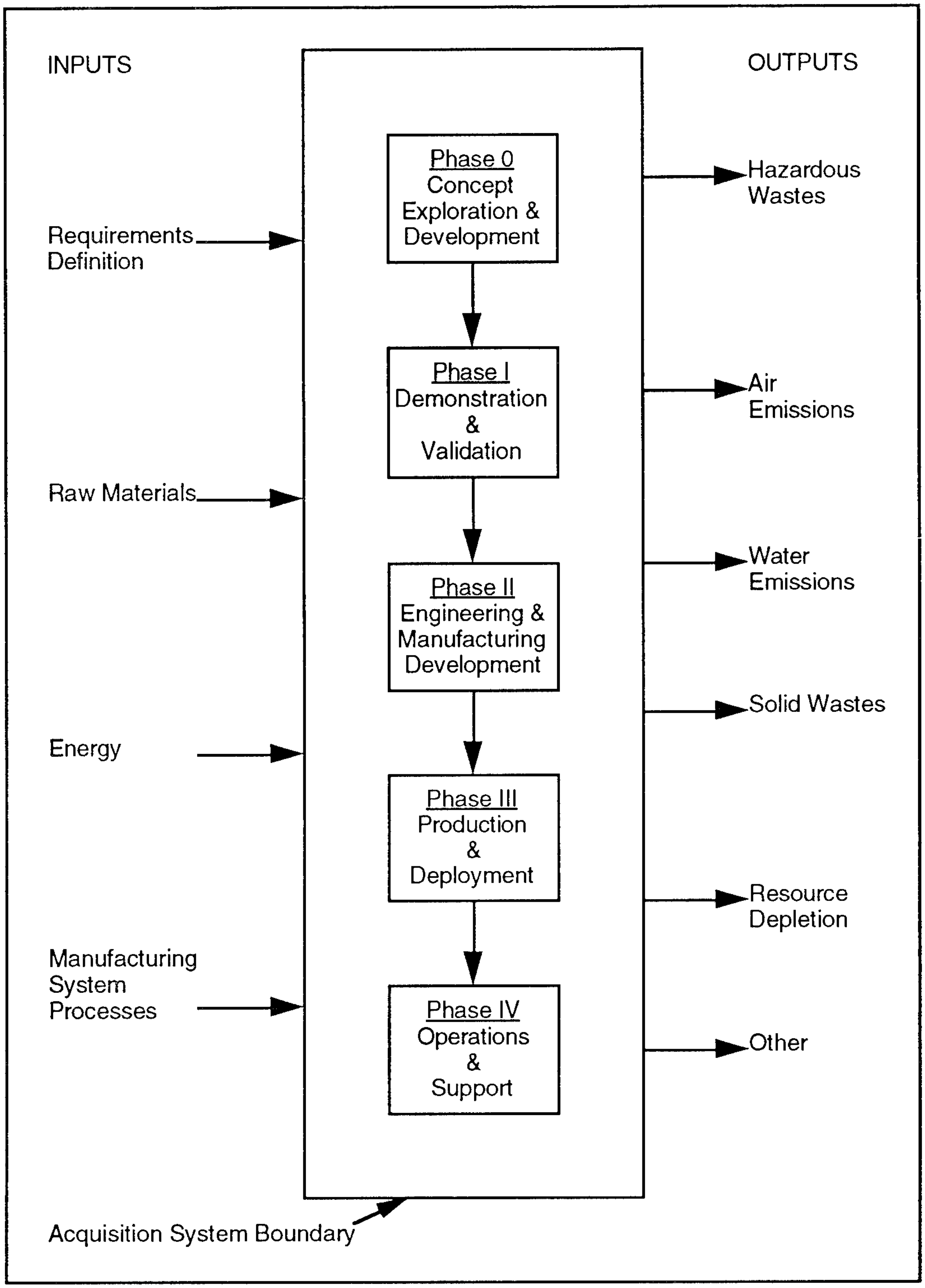

Figure 2. Input-Output Analysis Framework

generally made available to the public.

An LCA is composed of three phases. Phase I is a basic input-output inventory analysis. Figure 2 presents a conceptual framework for conducting this analysis, a process which can be applied to weapon system acquisition. A very important consideration during this phase is the amount of energy used during the production,

operation, support, and disposal of the weapon system. During Phase I, data are gathered on all the processes and intermediate products that go into the production of a weapons system. These data are gathered for all phases of the acquisition process. This includes data on the raw materials used in the system, manufacturing processes, operational procedures, maintenance requirements, and ultimate disposal.

As stated previously, most LCA studies have been conducted by private firms and are not available to the public. However, a few are, and they have gained considerable publicity. Among these are a 1990s study by Proctor & Gamble on disposable versus cloth diapers and a study on the polystyrene "foam" containers used by McDonald's Corp. These studies will be described in greater detail later. The conduct of a LCA is a time consuming and, therefore, expensive process. This helps explain why, out of the millions of products and processes in the U.S. economy, only a handfull of studies (approximately 100) has been performed.

The most efficient approach to performing an LCA is to utilize existing life-cycle cost models where possible. These models contain data on the "nuts and bolts" of the components and subsystems that go into a weapon system and can form the basic level of an LCA. The next higher level in the assessment will be the parametric level which will quantify system performance and introduce risk factors. The third and highest level of the assessment is used to evaluate the life-cycle impact on the total environment - the environmental burden. Figure 3 presents a conceptual model for this process.

Phase I of an LCA as presented above is fairly well defined. Depending on the scope of the LCA, additional phases might be required. Phase II deals with impact analyses during which emission quantities and their relative environmental consequences are evaluated. Whether or not Phase II is performed depends on the objectives of the study. If an impact analysis is desired, it is imperative that what constitutes an impact in the context of the LCA be defined initially. Typical impact definitions range from human health risks to habitat alterations. Phase II is not well defined at this point in time because the relationship between an environmental emission identified in Phase I and a harmful effect is not well understood. Furthermore, no recognized method exists for comparing various environmental impacts. For example, if the input-output analysis

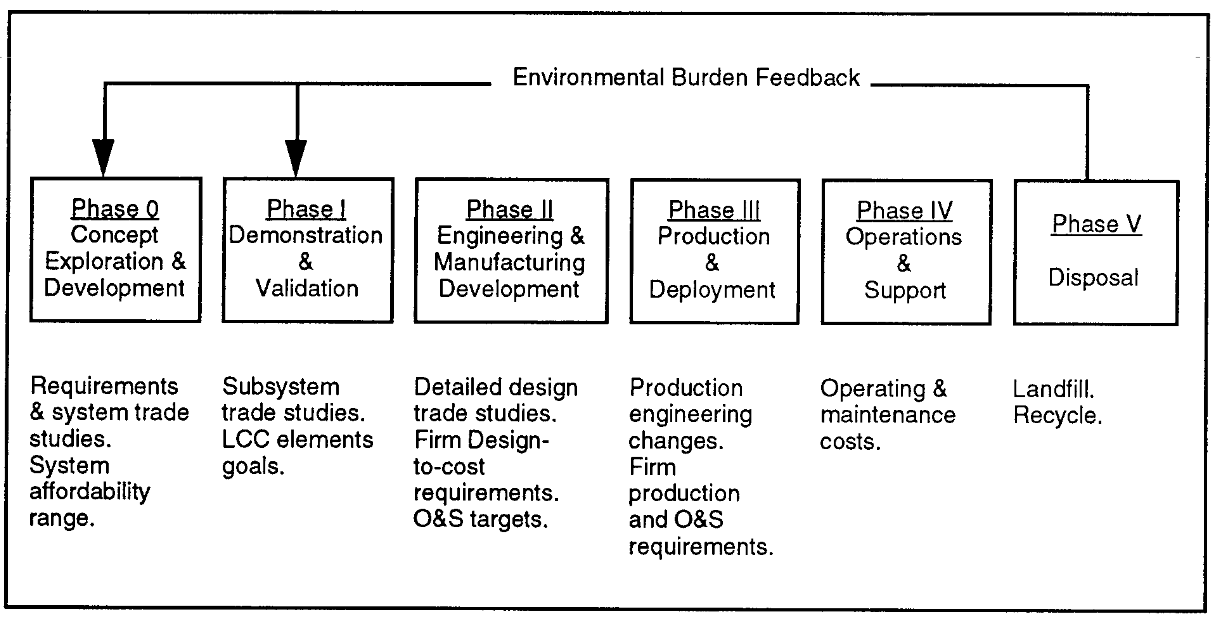

Figure 3. LCA Analysis Framework

performed in Phase I reveals that a specific production process will generate a pound of sludge as a waste product, is it worth the consumption of additional BTUs of energy to eliminate it?

Phase III deals with improvement analyses. Certain aspects of improvement analyses are also not well defined. These typically revolve around making value judgments when considering whether to change a process or activity to create less solid waste but perhaps more air pollution. This type of shortcoming has been identified and discussed previously when describing Phase II activities. However, some types of improvements can be identified which don't involve a decision of this nature. These improvements are implemented and result in significant cost and/or pollution reduction as shown in the case studies described previously.

While providing a useful tool to establish the environmental burden of a specific weapon system which is produced and maintained using specific procedures and standards, LCAs are not the complete answer. The biggest drawback is that there are no agreed upon approaches or standards to use when evaluating a system being acquired. Value judgments must be made. For example, is it better to use more BTUs from a nonrenewable energy source, such as coal, possibly increasing air pollution during the energy generation process, to produce a product which will be more biodegradable upon its final disposal (less solid waste)? Normative questions such as this cannot be answered using LCA.

Lack of standards can also produce inconsistent results. The Proctor & Gamble and McDonald's studies mentioned earlier are two cases in point. In the Proctor & Gamble study, it was found that cloth diapers consumed more than three times as much energy, from cradle to grave, as disposables. However, a study sponsored by the National Association of Diaper Services reported that disposables consumed 70% more energy than cloth diapers. This discrepancy was traced largely to accounting methods used in measuring energy consumption during the processes (1).

In the McDonald's study performed by environmental consultant Franklin Associates Ltd., polystyrene "foam" containers were shown to use less energy in the production process, pollute less, and create <u>less trash by weight</u> than paper containers. However, a study by environmentalists concluded that foam is not biodegradable and makes <u>more trash by volume</u> than paper. McDonald's eventually phased out the foam. A few months later, a Canadian chemistry professor published a study suggesting that foam cups were better environmentally than the paper ones (5).

LCAs are data intensive and this creates a potential problem. It is difficult, if not impossible, to obtain detailed basic data for the entire life cycle of the product/activity being studied. Also, some data may not be available because they are proprietary. In these types of circumstances, the use of industrial averages obtained either from government data bases or trade associations can be used to fill data voids. Where possible, sensitivity analyses should be performed to determine if some data have a disproportionate impact on the assessment. The existence of such data would necessitate greater care and accuracy when obtaining them.

Given the problems mentioned above, of what use can an LCA be in the acquisition process? There are three primary benefits which can accrue from the completion of an LCA:

- LCAs are useful in identifying pollution prevention opportunities in various production processes used in acquiring weapon systems.

- One of the major reasons for conducting an LCA is to compare different approaches to the development, production, operation, and disposal of weapons systems. Given the level of inaccuracy in determining the absolute level of environmental burden produced by various processes, the

difference between them is useful information in deciding which is the best.

• The DoD is a major consumer in the economy. By requiring that its suppliers provide some type of LCA for the products they sell, DoD can have a significant impact on the total burden placed on our environment.

CONCLUSIONS

Until recently, one of the basic underlying assumptions of mankind was that processing mankind's waste products was a primary function of this planet. That view is slowly changing as the difficulties of disposing of waste material continue to mount. Achieving the level of environmental awareness and sensitivity necessary to ingrain pollution prevention into the acquisition process will not be an easy task. Despite its shortcomings and limitations, LCA provides an analytical tool by which this process can begin. What is needed is a DoD effort to conduct an LCA on an existing weapon system in order to quantify the benefits that could be obtained using this methodology. Existing life cycle cost models provide a possible starting point that would build on currently available data.

Pollution prevention by DoD weapon systems will require more than developing new tools and changing the technology involved in the production process. It will require changes in the mindset of the people who develop, produce, and purchase weapon systems for the DoD. Perhaps the only way to achieve such a mindset change is to establish a national commitment similar to that which helped land a man on the moon 26 years ago.

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Notes on the Satisfiability and Completeness of Performance Specifications

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ABSTRACT

This paper addresses two logical consequences of specifying products strictly in terms of their performance. The first is derived from conclusions by mathematical logicians that certain types of problems are unsolvable because of their great computational difficulty. A close correspondence is cited between one such type of problem and the task of evaluating performance specifications for engineering feasibility. This correspondence accounts for the great difficulty that engineers seem to have in separating design from performance in specifications. The second logical consequence results from practical constraints on the length of documents, and a simple method is offered for avoiding the difficulties it might cause.

INTRODUCTION

The customary view of the systems engineering process prescribes that designers begin their efforts at developing a new product by first tabulating and validating a list of performance requirements. The validation part entails a careful check to be certain that all of the requirements are essential and that meeting them is economically achievable. In Defense work, our usual objective for the past several years has been to translate the list of validated requirements into a performance specification suitable for inclusion in a Request for Proposals and then to award a contract for the completion of the product's design and development.

However, Government engineers and scientists have had considerable difficulty confining themselves to specifying requirements based only on performance. Despite the long-standing policy that dictates the use of performance specifications, very few purely performance specifications have been produced. Most have consisted of a mixture of performance and design requirements. The result of such non-compliance has been the establishment of a formal review process to ensure that the policy is adhered to in the future.

Believing in the premise that people really want to do their jobs correctly, and will generally do so if at all possible, I was led to ask what aspect of the process produces such a disparity between policy and practice. My study of the theoretical aspects of specification writing has revealed that the disparity may result from the nature of the logical relationship between performance and design and from the difficulty involved in anticipating the design solutions derivable from a baseline of purely performance requirements. Such difficulty suffices to explain why engineers are not prone to base their reasoning on a set of numerous performance requirements. Perhaps it also explains why technological advancement usually proceeds in small steps by incremental refinement and improvement of existing designs.

PERFORMANCE SPECIFICATIONS AS LOGIC PUZZLES

The easiest path towards understanding why it is difficult to find designs that satisfy a large set of performance requirements is to see how closely the task corresponds to the process of solving certain types of puzzles encountered in the study of logic.

Most of us are familiar with the type of logic puzzle that consists of a series of statements about members of a set of people or objects and requires that one reach a conclusion satisfying all of the given constraints. A classic example is Lewis Carroll's pork-chop problem[1], which begins:

> (1) A logician, who eats pork chops for supper, will probably lose money;
>
> (2) A gambler, whose appetite is not ravenous, will probably lose money;
>
> (3) A man who is depressed, having lost money and being likely to lose more, always rises at 5 A.M.;
>
> (4) A man, who neither gambles nor eats pork chops for supper, is sure to have a ravenous appetite; . . .

The eleven additional premises, which are not necessary to illustrate the point at hand, are given in the endnotes.

The solution to the pork-chop problem is far from obvious. Even the number of people involved in the solution is not evident before the problem is solved. This is because there are eleven variables involved and fifteen equations governing their interrelationships, each constraining either three or four variables. Such solutions are beyond the capability of the unaided human mind, which Miller has shown to have a short-term memory capacity of only seven items, plus or minus two[2]. Today's approach to solving this problem would be to write a computer program that automatically formulates hypotheses and tests them for compliance with each of the premises. For problems of this size, the necessary exhaustive search can be completed by computer in a short time, but the time required would increase very rapidly if additional premises were added.

By the way, those who would entertain themselves by attempting to solve the pork-chop problem are advised to review the literature first because some of the semantics and punctuation rules have changed since the Victorian era when Lewis Carroll formulated it[1]. Such seemingly minute details as the semantics of English articles and rules for comma usage are also extremely important to specification writers[3].

The parallel between such logic problems and performance specifications can be seen by recognizing that each of the given assertions is a statement about the behavior of some member of the group, and that the solutions are sets of assertions about the state of being of the members. The process used in solving the problem identifies sets of facts that constitute solutions. This is essentially the same process required when searching for designs that satisfy a set of performance requirements. The main recognizable difference in form between the logic problem and the specification is that the specification requirements are written entirely in the future tense.

As stated above, the complexity of the problem depends upon both the total number of variables and the number of variables affected by each premise. In the case of the pork-chop problem, these are relatively few, but sufficient to make the problem too difficult for an unassisted human mind. In the case of the specifications, the number of statements is very large. My research revealed that one training device specification

stated thousands of separate requirements. The interrelationships between statements in the specifications are not always explicitly stated, but they exist nonetheless and often depend upon decisions made in the course of design.

In addition to the myriad of man-made performance requirements that must be satisfied, there are laws of nature and practical constraints that must be satisfied as well. Every designer knows how a seemingly minor change in requirements often produces a ripple effect that requires the readjustment of numerous design details throughout an entire system. For example, many specification requirements affect not only the properties they explicitly mention, but also affect weight, power consumption, heat dissipation and all the "-ilities." Likewise, every performance requirement imposed on software has an impact on the memory requirements and processor speed requirements. Practically every requirement affects cost, which is usually constrained by the figures given on the front page of the contract.

As each performance requirement is added to the list, it has to be evaluated for whether or not it is compatible with all the rest. Many functions each have to work both independently and with all combinations of certain other members of the set. When the total reaches twenty of such compoundable requirements, the time to evaluate them, at just one minute per combination, would be just short of two years. Thirty such requirements would create a combinatorial explosion resulting in 2043 years' work.

While it is evident that we routinely apply mathematics to solve engineering problems involving large numbers of variables, one must recognize that such solutions depend upon the representation of physical phenomena by operations on real numbers, and continuity of the functions involved is generally essential to the solution methods. Such methods are not applicable to problems confined to the logical domain involved in the process of evaluating a product for acceptability. A product either meets each of the performance requirements specified or it does not. If it were to meet all but one requirement, and miss that one by just a tiny margin, a minor revision in the product's design to make it meet that one requirement might very well cause other performance characteristics to fall from acceptability. This is particularly true of the kind of highly optimized designs that are characteristic of Defense work.

SATISFIABILITY

There is one significant difference between the logic puzzle and the design problem: We know from the outset that at least one solution to the logic puzzle exists. Despite our best efforts to validate the performance requirements, until a product has actually been produced that satisfies all the specification requirements, we are never really sure that such a design solution exists. This, again, is especially true in Defense programs, where engineers are usually striving to advance the state of the art.

The existence of a solution for a logic problem is called "satisfiability." It is clearly a prerequisite to the more restrictive requirement for economic feasibility that we place on engineering specifications. Economic feasibility, in turn, is a prerequisite to the legal requirement of "possibility of performance." Clearly, one cannot base a contract on a set of requirements that cannot be met.

Modern logic theory tells us that determining whether or not a given set of premises is satisfiable belongs to a class of problems known as "NP-complete," and, by our analogy, the satisfiability of most every large set of specification requirements is also likely to be NP-complete. These are among the most time-consuming of all problems. Satisfiability for

problems that have the same format as the pork-chop problem but contain more than about twenty premises are not solvable in a human lifetime. For problems as large as our many-thousand requirement training device specification, the fastest conceivable computer system would take more space and time than the universe has to offer[1].

While it is not unusual to discover, well into the development of a new product, that some of the performance requirements will have to be compromised in order to avoid impossibility of performance, many development projects are completed smoothly. How can this be, considering we have argued quite strongly that determining satisfiability is often impossible?

The answer is that the systems engineering steps mentioned above are not really representative of the way in which performance requirements are derived. Studies of artificial intelligence have revealed that the human mind has evolved methods of reasoning that avoid the need to perform exhaustive searches. In conceiving a new product, the mind seems to approach the problem in the reverse direction. That is, the newly conceived product is usually an extrapolation from existing designs with which the systems engineers are intimately familiar. Their performance-requirement writing process is partly like that of the logic-puzzle writer, who starts out with the solution and writes the set of premises to fit the solution. For this reason, design is necessarily involved at a much earlier stage than what our process model for systems engineering postulates, and the necessity is a consequence of the manner in which all automata, including the human mind, must function.

THE "SHALL NOT" PROBLEM

In 1975, Puryear warned drafters of performance specifications that they "must activate practically every contingency with respect to the functional requirements of the product[4]," but he did not elaborate on the matter. The following discussion is intended to illuminate his statement and point out a logical flaw in our present approach to drafting performance specifications.

INCOMPLETENESS

Consider a universe, **U**, of performance characteristics. **U** is a set that contains every possible characteristic of every possible product. Of course there is no such thing as a universal product whose performance covers all of **U**, but every product, known and unknown, could have every one of its performance characteristics mapped onto **U**. In Figure 1, **U** is the background on which the diagram is drawn. Simple reasoning supports the assertion that **U** contains a countable infinity of elements. Design requirements do not map onto **U**. They may produce performance characteristics, which can, in turn, be mapped onto **U**, but design characteristics themselves are not in **U**.

Performance requirements can be mapped on U. They are merely a description of performance characteristics written in the future tense and express requirements for the performance of a possibly not-yet-existing product. A set of performance requirements is usually called a performance specification, and can be separated into two subsets: **S**, which consists of those statements that express requirements that the product have certain performance characteristics; and **S'**, which consists of statements requiring that the product not have certain performance characteristics.

In a formal specification, **S** and **S'** would be complete. That is, they would totally and completely describe everything about the product. If we were to write a formal performance specification and add the statement "The product shall do nothing else.," the additional statement would have no effect because everything necessary would have already been addressed. Formal

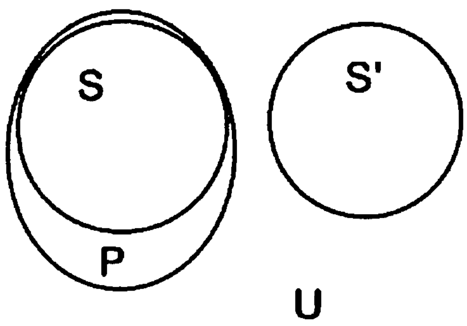

Figure 1. An informal specification and a product on the performance plane.

specifications therefore usually contain a very large but finite number of requirements. Formal specifications must also be written in formal languages that are, of necessity, very limited in scope. The only time one ordinarily encounters a formal specification is in the code of a computer program, which, by the way, is a formal design specification, not a formal performance specification.

All other specifications that we ordinarily encounter are informal. In informal specifications, S describes performance characteristics that the specifier considers important enough to mention, and S' forbids performance characteristics that the specifier considers important enough to forbid. Adding the statement "The product shall do nothing else." is not appropriate in such cases, and would probably constitute breach of common sense or a requirement to violate some law of nature.

For example, if the color of the specified product were not mentioned, the only way the product could be acceptable under a "do-nothing-else" requirement is by reflecting no light at all. The only things known to come even close to meeting such a requirement are the sky on a clear night and holes in a very large container whose inside has been made as nonreflective as possible. All products other than holes and the clear-night sky would thus be excluded from acceptability by the "do-nothing-else" requirement.

Given the necessity that performance specifications have to be open ended, it is therefore possible that a product, shown as **P** in Figure 1, may have some performance characteristics that are undesirable but not forbidden by **S'**. Such characteristics might make the product unsatisfactory for its intended use, but nonetheless acceptable according to the specification. More often than not, such undesirable characteristics are corrected by redesign in accordance with an engineering change proposal. Occasionally, such a characteristic goes unnoticed until after the product is put to use.

AN ELEGANT SOLUTION

Clearly, this problem will not be solved by attempting to forbid all possible undesirable performance characteristics, since their number would be enormous. A good alternative would be to deviate from the prescribed outline for specifications and move the usual items presented under "Intended use" to the "Requirements" section. Under traditional specification outlines, "Intended use" appears under "Notes," which does not contain mandatory requirements. Fitness for intended use is a perfectly legitimate performance requirement, and specifiers are well advised to always make it a requirement and to provide a detailed description of its basis.

CONCLUSIONS

In addition to the need for a minor revision to the standard outline for specifications, there are two conclusions that can be reached from the analysis presented. First, without risking impossibility of performance, we cannot permit personnel who are not intimately familiar with the design of similar products to haphazardly choose a set of performance requirements for a new product and then expect a contractor to produce a design that satisfies those potentially

unsatisfiable requirements. Second, the key to successful development of new products may be the care taken in limiting the number of requirements that are new to the task at hand and were not imposed on similar products that are already in use. By doing so, the design space that must be searched for solutions could be kept within the human scale. Perhaps a careful audit of specifications to count the "new" requirements would permit program managers to estimate the probability of later encountering engineering difficulties and thereby asess program risk.

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END NOTES

The remainder of the pork-chop problem:

(5) A lively man, who goes to bed before 4 A.M., had better take to cab-driving;

(6) A man with a ravenous appetite, who has lost money and does not rise at 5 A.M., always eats pork chops for supper;

(7) A logician, who is in danger of losing money, had better take to cab-driving;

(8) An earnest gambler, who is depressed though he has not lost money, is in no danger of losing any;

(9) A man, who does not gamble,and whose appetite is not ravenous, is always lively;

(10) A lively logician, who is really in earnest, is in no danger of losing money;

(11) A man with a ravenous appetite has no need to take to cab-driving, if he is really in earnest.

(12) A gambler, who is depressed, though in no danger of losing money, sits up till 4 A.M.;

(13) A man, who has lost money and does not eat pork chops for supper, had better take to cab-driving, unless he gets up at 5 A.M.;

(14) A gambler, who goes to bed before 4 A.M., need not take to cab-driving, unless he has a ravenous appetite;

(15) A man with a ravenous appetite, who is depressed though in no danger of losing money, is a gambler.

According to Poundstone, a solution to the pork-chop problem is: "An earnest logician always gets up at 5 A.M. and sits up till 4 A.M."

FEDERAL ACQUISITION AND THE POLITICAL PROCESS

Political Market Structure Constraints on Post-Cold War Acquisition Reform

by

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Abstract

The broader political and economic context in which major defense contracts are let has far more long-term significance for cost and for the preservation of important defense production capabilities than the micro-level issues of specifications and oversight. Furthermore, although some detail-level reforms are unquestionably desirable for their benefits in streamlining the acquisition process, other announced directions for reform fail to recognize important contextual constraints and may actually compound the inherent difficulties for acquisition posed by political and technological uncertainty. Acquisition reform initiatives which rely on market forces to impose efficiency will be thwarted by politically-induced market failures, and an oversupply of major production lines will maintain high overhead cost in the defense industry. Moreover, the current response to rapid technological change in commercial products and to even faster change in the political winds is a holdover from the Cold War habits which led to concurrency: initiatives to speed acquisition and to link it to "off-the-shelf" technology cannot "catch up;" they simply compound projects' technological uncertainty and lead to more unfulfilled expectations. A more sensible response to the acquisition crisis would slow the entire process.

Introduction

The broader political and economic context in which major defense contracts are awarded has far more long-term significance for weapons system costs and the preservation of important defense production capabilities than the micro-level issues of contract specifications and oversight. Furthermore, although some detail-level reforms of the weapons acquisition process are unquestionably desirable for their benefits in streamlining the acquisition activities, other announced directions for reform fail to recognize the important contextual constraints and may actually compound the inherent difficulties for acquisition posed by political and technological uncertainty.

During the Cold War, a broad consensus on security policy was forged by the perceived threat from the Soviet Union. Acquisition problems were rooted in a vicious cycle of political and technological uncertainty in which new projects over-promised performance improvements based on not-yet-developed technology to satisfy the multiple political masters in the services, the Department of Defense, and the Congress. The tendency was to undertake concurrent development and production commitments, which led to expensive programs that failed to satisfy expectations. Because of the general agreement on the threat, the Cold War procurement system was largely protected from use as a political pork barrel; because expectations were too high, the system produced the best military equipment in the world, even in "failure."

With the Soviet threat now absent, the level of political uncertainty in defense programs has soared: there is no longer an agreed-upon strategic constraint on purely parochial interests. Large-scale acquisition projects are generated to maintain concentrations of employment and incentives to preserve historically-important corporate name plates. Acquisition reform initiatives which rely on market forces to impose efficiency will be thwarted by politically-induced market failures, and an oversupply of major production lines will cause continuing high overhead cost in the defense industry. Readiness budgets will be squeezed as the overall defense budget ceiling lowers. Moreover, the current response to rapid technological change in commercial products and to even faster change in the political winds is a holdover from the Cold War habits which led to concurrency: initiatives to speed acquisition and to link it to "off-the-shelf" technology cannot "catch up;" they simply compound projects' technological uncertainty and lead to more unfulfilled expectations.

A more sensible response to the acquisition crisis would slow the entire process. In past eras of low threat, defense production capability was maintained by public arsenals. Today, the equivalent producers are privately owned, but the buying relationship should mimic the old, lower-pressure system. At presently-

envisioned, low rates of production, production efficiency is a less important concern than wasteful excess capacity and overhead.

The Dynamics of Cold War Defense Procurement

To analyze the problems facing the acquisition policy of the future, it is useful to set up a framework based on an understanding of the procurement problems of the past. Today's American defense industry was created by the pressures of the Cold War, as were the present government institutions which structure its sales efforts. Many of the core Cold War-era issues in the development of advanced weaponry are still with us today, but in different forms.

Issues Confronting the Cold War Acquisition Process

The fundamental point to make about the Cold War is that the United States approached its international and defense policies as if we were actually at war. Immediately after World War II, defense production was radically cut back, as it had been after World War I and all other previous American wars [1][31]. But quite rapidly, before the serious impacts of contraction were felt, the Soviet threat emerged and returned the U.S. defense budget to an expansionary path. The January, 1948, report of the President's Air Policy Commission (the Finletter Board) suggested rapid increase in aircraft purchasing to the high level of 30-40 million airframe pounds annually in addition to civilian demand to provide a sound basis for emergency production expansion [25]. Although prevailing American economic ideology (and Truman's attempts to hold the budget in balance) prevented the military budget from swamping the civilian economy, a substantially higher budget share for defense procurement than in any previous era of "peace" was enshrined in the Cold War political system [7]. Cyclical variations in the budget continued, but the broad constant was an elevated spending level [14].

Each service adopted a different strategy for spending its procurement budget, but all involved relatively high-rate acquisition of advanced weaponry [4]. Very soon after World War II, the goal of defense production began to shift from pure mass production to innovation and research spending [2]. Strategists suggested that America's natural comparative advantage in competition with the Soviets was in quality rather than quantity [9]. Nevertheless, Congress was constantly urged to build large numbers of weapons. "Small" quantity production was quite large: 1,923 B-47s were build during the program's short life from 1944 to 1957. As unit costs of high-tech aircraft soared, total production dwindled -- but the 100-aircraft run of the B-1B would be quite large by today's standards. Meanwhile, new technologies were purchased very quickly, often before designs had been fully tested and all modifications were completed [3]. The hurry-up mentality is confirmed by the continued use of concurrent development strategies even after it had become quite clear from experience that it often led to cost over-runs, technical difficulties, and extensive retro-fitting programs, which called into question the strategy's expected deployment date advantage [3][32].

All weapons development programs, in fact, were beset with two types of uncertainty which made their "success" an unlikely prospect. One uncertainty derived from the nature of high-technology weapons ("technological uncertainty"); the second resulted from the fragmentation of political authority in American government ("political uncertainty"). These two uncertainties interact, and in fact can be applied to all American weapons development programs, including those of today [29].

Technological uncertainty is a product of the process of invention and expansion of knowledge. In the quest to ensure that the United States possesses the best weapons, the military constantly pushes the limits of what is possible with current technology. Moreover, even as we attempt to develop affordable, deployable defenses, the threat becomes more capable, and the interaction of competing technologies adds to uncertainty. If we had a fixed objective,

we might be able to pursue a leisurely development process followed by an extensive period of test and evaluation before large-scale production. But with a shifting threat, sequential development appears impractical: weapons become obsolete before deployment. We simply cannot know whether the missions set for our weapons are possible in many cases.

On the political side, it is a basic, often-ignored fact that the government of the United States was created with the explicit intent of constraining the exercise of political power. The Founding Fathers created a system of checks and balances that would pit "interest against interest." Most broadly, the interests of the Executive balance those of the Congress, but the fragmentation of authority also exists within each branch. The Department of Defense consists of many offices and agencies, and even the services are divided into weapon communities, committees, commands, and offices. Within a service branch, one community may be deeply committed to a weapon or capability while another may be indifferent or even hostile. Events constantly shift power amongst these factions. In the legislature, the House and Senate have different bases of representation, terms, and interests. The agglomeration of locally elected representatives has an obvious local focus, and, within each house, committees struggle for dominance. Congressmen worried about the next election are often more interested in claiming credit for enacted changes than in the long-term effects of those changes and abstract notions of the "national interest" [18]. The strategic climate of the Cold War exercised a restraining influence on pernicious Congressional activity [17]. However, with the disintegration of the Soviet Union, this restraint is now absent, and there is a new degree of political uncertainty [30].

Cold War Procurement Outcomes

The combined effect of political and technological uncertainties led some Cold War weapons programs to be perceived as successes, while others were seen as dismal failures. One analyst recently inventoried the academic literature discussing major systems acquisitions and classified 53% of the nineteen cases as successes to 47% failures [10].

Critics of the Pentagon's approach to weapons development, emphasizing the supposed failures, pointed to rising costs and shortened production runs as a threat to the viability of America's defense industrial base. Even so, Jacques Gansler, for example, acknowledged that the weapons systems purchased during the Cold War were "extremely capable" [8]. The Office of Technology Assessment reported in its April, 1989, survey of the defense industrial base that "the United States was the undisputed technology leader of the world. U.S. military equipment was meaningfully and undeniably more sophisticated than that of the Soviet Union, and our allies sought American technology for their own defense efforts" [33]. The report went on to question the future of that supremacy given the possibility that Soviet technology would catch up, but those fears have since been proven unfounded by the collapse of the Soviet Union. America's absolute level of technological strength was never really in question.

Cold War-era Acquisition Reform Efforts

Efforts to reform the weapon acquisition process are nearly constant, although major initiatives have been undertaken erratically. The defense budget was a major proportion of total government spending, making it a regular political target. Moreover, many procurement programs were perceived as failures due to the unreasonably high standards set in response to the inherent political and technological uncertainties. And in the American system, the natural response to a perceived failure is an attempted reform.

At the same time, the vagaries of the international situation constantly led to changes in the evaluation of America's security and consequently to new calls for better, cheaper weapons -- which often required a political explanation for why the previous acquisition system had failed and

hence a new, blue ribbon commission-led reform effort.

Acquisition reform as a political tool led to considerable variation in its actual implementation. In circumstances of high international tensions, reforms were proposed but generally not implemented. Defense budgets tended to be high, and the trend was upwards. Congress and the public were temporarily willing to bear high costs in order to ensure the security of the United States. Nonetheless, criticism of weapon procurements arose because of these high levels of expenditure, because real inefficiencies unavoidably occurred during rapid expansions, and because criticism of inefficient procurement is a "safe" way to criticize high levels of defense expenditure. Even hawkish politicians viewed acquisition reform as protection against being branded as always willing to give the military a free hand. With international tensions high, studies were commissioned, but they served primarily as "smoke screens" to defend the level of military expenditures [12]. Even serious reform efforts were unlikely to be implemented for fear of disrupting the buildup and undermining national security.

The contrast is to the brief periods of détente during the Cold War. The defense budget generally fell with the tension level, and both the military and the civilian defense establishments supported efforts to economize. Formal implementation was therefore more likely, because the reforms were a useful political tool to stave off larger program cuts.

The McNamara reforms of the mid-1960s are an example of implemented reforms that still failed to improve perceived procurement performance [11]. The acceptance of the bureaucracy was coerced, and the reforms were largely put into place. The Total Package Procurement policy failed simply because it was ill-conceived: it did not take account of the technological uncertainty always present in the weapons development process. Forcing the financial and contracting structure to treat weapons development as if systems were technologically mature while still demanding prodigious advances to meet ambitious operational goals was fated for disaster. McNamara's reforms illustrate the futility of efforts that ignore the key structural relationships of the American political system and the associated and inter-related technological uncertainty characteristic of our acquisition system.

Current Trends in Post-Cold War Procurement Policy

In the post-Cold War period, the context in which procurement institutions operate has radically shifted, but the institutions themselves have not changed. The abatement of the Soviet threat has left a vacuum where there used to be international tension, and the defense budget has shifted downward in secular rather than cyclical fashion for the first time in fifty years. The conditions are ripe for a major reform, but the present effort, by relying on outdated concepts, continues and even exacerbates Cold War political pathologies.

Issues Confronting the Acquisition Process

The $252 billion defense budget approved by Congress for fiscal 1995 has brought spending just below the 1979 level in real dollar terms, signaling the end of the 1980s boom cycle. But with the absence of a superpower threat, there is no national security reason to keep the budget at even this level. To the extent that the defense budget has been propped up in the 1990s, it has been to protect the jobs of defense industry workers, covered by political rhetoric about the industrial base. With cuts only now threatening the defense industry's core capacity rather than the enlarged size built up in the Reagan years, the real political action is just about to begin (even acknowledging that the cuts so far have hit some particular sectors harder than the industry-wide average).

The FY95 authorization bill was chock full of industrial base references, from the "bomber industrial base" to the "ration industrial base" [28]. While Newt Gingrich, the Speaker of the new Republican-led Congress, rhetorically supports a shift in policy from old idea of the "industrial base" to the Twenty-First Century notion of an "information base," practical GOP

implementation proposals favor saving big Pentagon programs such as the B-2 bomber, missile defense systems, and the Seawolf attack submarine -- protecting concentrated interests in employment [26].

To combat the perceived defense industry over-capacity, the government has none too subtly spread the word that mergers and consolidations will be looked upon favorably by anti-trust authorities. The recent approval of the merger between Lockheed and Martin Marietta has been hailed as a signal, and defense analysts speculate that competitors who might face "unfair" competition from the new giant have not vigorously opposed the deal because they fear retaliation from the Pentagon, which strongly supports it [23]. The trouble with the current approach to industry consolidation that "lets the market decide" which firms will survive is that contractors, left to their own devices, are responding to the post-Cold War era not by emphasizing efficiency or weapons' capability, but instead by lobbying. Voluntary corporate restructuring is painful: share prices drop, and workers lose their jobs. Shareholders and workers can instead beg Congress for a restoration of their budget life-line

Although recent mergers appear to be a kind of restructuring, they are part of a lobbying strategy. Technical "synergies" between firms are often exaggerated, as are manufacturing plant consolidations. For example, most of the facilities closed after the Northrop-Grumman-Vought merger were already scheduled for closure by the separate companies [5]. Similarly, Lockheed, primarily an aircraft company, and Martin Marietta, primarily an electronics and space company, do not operate in many of the same areas of defense contracting. Opportunities for consolidating post-merger production are minimal, and any technical synergies which might be achieved are blocked by an FTC-imposed "firewall" limiting inter-division communication in the interest of preserving market-like competition. The genuine logic of these Wall Street transactions is either an industry belief in the political clout of large organizations (which would presumably lead to non-market, non-strategic acquisition outcomes) or an industry demonstration of responsiveness to the perceived requirements of their government customer (also in an attempt to salvage some politically-induced contracting) -- or both [20].

Post-Cold War Procurement Outcomes

At present, there are somewhere in the vicinity of eight production lines producing or capable of producing military aircraft, depending how one counts. McDonnell Douglas has two lines, Lockheed has three, Boeing has one, Northrop Grumman has one, and some would also count the now-"cooling" Northrop Grumman facilities which used to make F-14s and the Rockwell plant which used to make B-1Bs. Two years ago, it appeared that Northrop's B-2 line would naturally close, trimming the stable of going production plants, but it has instead been the first prominent instance in which job-oriented political incentives have preserved an extra production line. In the FY95 budget, the Air Force spent $150 million to keep the line "warm," if not producing new aircraft; now, the debate has re-opened for additional production orders starting in FY96, although no one can pose a credible military scenario in which American forces would be called upon to use even the twenty B-2s which we already have purchased.

The primary effect of this institutionalized overcapacity is to force the procurement portion of service budgets to unreasonably high levels. Even if the acquisition of all the various models of advanced weapons could be justified on strategic grounds, the low rate of production called for by post-Cold War politics bars efficient production at each of the individual plants [16]. The ratio of overhead spending to actual operating costs of defense plants is soaring -- with overhead defined not in terms of corporate headquarters costs and the costs of "doing business with the government" but in terms of real estate costs, energy costs, artificially large workforces not taking advantage of scale economies, etc.

The underlying irrationality is caused by the Cold War style of defense procurement. Defense procurement spending comes in large packages only --

enough to sustain a production program at each shot, including all the overhead expenses. Political cover for Congressional efforts to save jobs comes in the guise of industrial base rhetoric, which seems to require actual production; what was lost during the Cold War was the ability of the American procurement system to support workers and design capability without paying for the high-rate, large-scale production contracts demanded by private industry -- an ability inherent in arsenal-style development and production.

Post-Cold War Acquisition Reform Efforts

The current acquisition reform effort fits well into the framework presented in the discussion of Cold War reforms [15]. Historical experience suggests that recommendations of major pro-reform reports are implemented only in times of relatively low international tension, and although security crises in Bosnia and North Korea regularly occupy newspaper front pages, direct threats to the United States today are small compared to those of the Cold War. Just as proposals were rapidly implemented during the détente of the early 1970s, the Federal Acquisition Streamlining Act of 1994 adopted many suggestions from the January, 1993, report of the Acquisition Law Advisory Panel (Section 800 Panel). The announced goals were to give acquisition corps members greater flexibility in procurement decisions; to bring new, traditionally-commercial suppliers into the defense business and thereby increase access to cutting-edge technology; and to speed development programs by cutting through bureaucratic red tape. The mentality is such that the defense industry is supporting even faster reform than the new law offers through "a challenge to 'pick the lowest hanging fruit' ... [and] to adopt industry's 'best business and production practices'" [13]. The difficulty with these reforms, in fact, is that they fit too well into the Cold War framework: the thinking which motivated them is stuck in the old, political paradigm of acquisition reform which is inappropriate for the post-Cold War environment.

The effectiveness of the reform in meeting its stated efficiency goals rests on political and technological uncertainty. One rationale in Secretary Perry's statement on the need to integrate defense and non-defense industries is to provide the military sector with faster access to advanced commercial technology [24]. The recent demonstration of the military benefits of technological superiority in Desert Storm and an increasing emphasis on high-technology economic competitiveness in the commercial sector make capturing some of commercial America's success for the defense sector politically important. Unfortunately, in major military programs with long lead times and production spread over many years (because of high unit costs for complex systems), the pace of technological change is much faster than the pace of contracting in even a simplified procurement process. The best possible streamlining program will never allow "technology insertion" from the commercial sector into military programs to catch up with the pace of innovations. A reform that provides the military greater access to changing commercial technology will only increase the technological uncertainty inherent in the procurement process, thereby threatening the programs' success. At best, technological goals will remain modest and the new access to the commercial market's technology will not have helped the military, but the benefits of certain procurement regulations (which, it should be remembered, were not established capriciously) will have been lost. At worst, expectations for new military technology will be raised too high, leading directly to technological over-reach and program failure.

At the same time, political uncertainty has radically increased in the post-Cold War world. The political structures of the federal government have not changed, and, in a rare instance of inter-branch cooperation in defense policy, the recommendations of the Congressionally-sponsored Section 800 panel and of the Vice President's National Performance Review are in basic accord. On the other hand, obtaining agreement about the requirements of future weapons systems will be increasingly difficult in a world with high

levels of political disagreement about America's military strategy. There is no longer an obvious superpower adversary limiting this political conflict, as there was even during the low-tension era of détente. Integrating the commercial and military industrial bases is likely to prove impossible as the political process frequently changes its perceived strategic requirements, reacting only to the most recent "threat."

Because the Section 800 panel adopted a managerial approach, using efficiency as its sole metric, and because it neglected to consider fundamental environmental shifts in the post-Cold War world, its recommendations are unlikely to be effective. Problems will arise despite the passage of the implementation vehicle at a time of low international tensions and despite the unusual legislative-executive agreement on the goals of the reform. Those goals are simply the wrong ones.

A Proposal for "Real" Acquisition Reform

The 1994 procurement reform law was doubly pernicious from the perspective of successful defense budget cutting. Not only will the specific provisions of the law run aground on the Cold War nemeses of political and technological uncertainty, but the perception that the recent reforms were on the right track further diverts the policy process from the true path. Calls for pro-efficiency changes in manufacturing strategy -- with answers expected from the Air Force's Lean Aircraft Initiative, the Agile Manufacturing Enterprise Forum, and within-industry moves to Total Quality Management and its equivalents -- miss the basic observation that the leanest form of manufacturing is the production of no weapons at all. Shaving efficiency losses out of production budgets matters when production runs are long, not when a large order is for twenty aircraft spread over five years. At such low-rate production, the focus on within-plant efficiency should be minimal; instead, the issue at hand is how many plants to keep open.

An Activist Policy Towards Defense Company Mergers

The elements of the right answer for post-Cold War acquisition reform already exist in nascent form. Although the Department of Defense has not played an active role in pairing up defense firms for mergers, there is a working merger policy which has helped to eliminate a small number of duplicative defense facilities once two private firms have decided to combine their operations. Martin Marietta was reimbursed some $80 million by the government for costs incurred in moving the General Dynamics Space Division facilities which it purchased from San Diego to Denver; similarly, Hughes Missile Systems received between $300 and $400 million in restructuring cost repayments relating to the move of the former General Dynamics' missile operations in San Diego to Hughes' Tucson, Arizona, operations center [34]. The announced policy is to pay restructuring costs when it can be shown that the prospective savings to the government in terms of lower overhead costs are greater than the restructuring charge itself, but because the program uses U.S. government money directly to close plants and lay-off workers, it has been controversial politically [6]. Unions have begun to protest the practice, and Representatives of districts in which plants have been closed have asked whether all restructuring cost payments should go to corporations and shareholders rather than also acknowledging the adjustments problems faced by workers [19][21].

The issue is likely to come to a head in the Hughes case, where a competing defense firm has raised the issue of competitive fairness: the merger policy payment helped make Hughes a more efficient producer of the Tomahawk missile, placing McDonnell Douglas at a relative disadvantage in bidding on the major contract for the next five years of production. McDonnell is quite right that they were treated unfairly, and although the particular contract award protest is still pending, the only outcome available in that forum to remedy the harm to McDonnell is

to re-divide the production contract among the two firms -- maintaining industry overcapacity, costing the government additional money, and sending the signal to defense industry firms that efforts to consolidate facilities will not be rewarded. A more appropriate repair to the Tomahawk situation would be a conscious policy decision to expand the current merger policy to help assuage the damage to the losing competitors, not just to encourage restructuring payments to acquired firms whose facilities were closed. What McDonnell needs is a form of "severance pay" for services rendered during the Cold War, an exit subsidy to help them leave the missile business.

Overcoming Political Market Failures

Ironically there is a policy to pare the capacity that the government itself maintains for weapon development and production, but not one yet for main problem. The Base Realignment and Closure (BRAC) Commission has in several rounds removed some of the government's capacity when it has closed or merged various arsenals, shipyards, repair depots and military laboratories in order to eliminate what is usually referred to as the Department of Defense's burdensome logistical tail. The procedures for realignment and closure of the facilities is intentionally insulated from politics. Neither the Congress nor the President can protect a particular facility at the behest of a local community once it has been designated by the BRAC as excess. Instead, the entire set of BRAC recommendations must be accepted or rejected as a package.

The contractors have encouraged the closure of the arsenals in the hope of gaining the work that was once assigned to these facilities. But most of the work involved in weapons development and production is already in the hands of the contractors. During the cold War there was a definite shift toward privatization. Relatively few government arsenals, shipyards, and the like, in fact survived to witness the collapse of the Soviet empire. Because of this, the consolidation that the current closures of arsenals generates will do little to solve the overall excess capacity problem in defense. The BRAC does not apply to private arsenals system that we have created during the last fifty years to supplement and then replace the public arsenal system

With the BRAC process, as limited as it is, already flagging because of political pressures, it is difficult to see the route to the structural changes that are needed. Complicating the situation is a politics that has the parties or at least the Congress and the President competing to add to rather than subtract from defense spending in the face of mounting federal deficits. The belief persists that defense allocations will soon turn up dramatically to meet a new threat or at least to keep the various production lines open and host communities happy.

But if the turn up does not materialize because a major foreign challenge fails to appear and domestic entitlements absorb whatever resources taxpayers are willing to provide then the armed services, as custodians of national security, will have to muster the political will to alter the government's relations with its private arsenals. Instead of multi-billion dollar weapons procurement we need the steady nurturance of core weapon technologies, the maintenance of key skills rather than the rush to field new weapons. The hectic activity of the Cold War has to be supplanted by the quietude of a watchful waiting that mark years of peace. America needs to learn to hone talents for war that are likely not to be in much demand, but have to be ready when needed. It's a problem we know exists in nuclear weapons and have yet to acknowledge sufficiently in the rest of our

military capabilities. Tinkering with acquisition reform is not the way to address it.

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Acquisition for Experimental or Test Purpose (AETP) and Acquisition Reform - Two Years Later

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OSD, Acquisition Reform

ABSTRACT

Acquisition for Experimental or Test Purposes (AETP) is an acquisition reform initiative which addresses the inability to acquire hardware and limited testing services for small dollar, one-time test or experiment procurement. Streamlining efforts originated at Wright-Patterson Air Force Base (WPAFB) in Nov. 1992, to allow certain **non-competitive** acquisitions. AETP acquisitions are small, one-time tests or experiments when data is needed for program decisions, technology insertion for existing items or products, to validate suggestions or ideas, determine commercial products' acceptability (or compatibility to our systems/personnel), etc. While the instant AETP acquisition is non-competitive, AETP can actually enhance long-range competition for large programs and enable better technology insertion or requirements definition. Local policy was developed at the Aeronautical Systems Center (ASC) WPAFB, OH based on the statutory authority then existing at 10 U.S.C. 2274 and 9504. Work remains to establish implementing language in the Defense Federal Acquisition Regulation (DFAR) and lower level Federal Acquisition Regulation (FAR) supplements before Contracting Officers and Program Managers can easily use the existing AETP statutory authority. This paper documents the background and colorful history of the AETP statutes, an overview of the field inputs which support the need for this authority, a case history of the F-16 Night Vision Goggles (NVG) program, and the changes necessary to the DFAR and Air Force FAR (AFFAR). Acquisition Reform involves all of us and, as the AETP story reveals, basic process changes are difficult and complex.

INTRODUCTION

The Acquisition for Experimental or Test Purposes (AETP) concept first received national exposure at the June 1993, Acquisition Research Symposium sponsored by the Defense Systems Management College (DSMC). The paper, titled "Acquisition for Experimental or Test Purposes (AETP)"[1], was presented at DSMC and published in the conference proceedings. The paper's thesis was simple: AETP statutes [then existing] at 10 U.S.C. 2274 and 9504 offered more efficient utilization of dwindling government and contractor resources, could save taxpayers money, would allow quicker technology insertion, give greater flexibility to conduct test programs for commercially available products or technology, and could generate more meaningful future competitions as technologies or products are proven to be useful to DOD. In addition, the 1993 AETP paper covered the legislative history, the genesis/need for AETP authority, the local policy and procedures implemented at WP AFB, potential applications, technology transfer, lease acquisitions, and issues remaining before successful implementation could actually occur.

A lot has happened since that 1993 paper was written! AETP remains a fascinating story of acquisition reform initiated at the field level which is now being considered for DOD wide implementation by the Acquisition Reform office. This paper discusses the AETP initiative which provides authority to acquire (or lease) hardware and limited testing services for small dollar, one-time test or experiment without competition. The non-competitive acquisition is a radical process change from the schedule, manpower, and strategy requirements of the Competition in Contracting Act (CICA). Discussion and real world example will show that, while the instant AETP acquisition does not provide for full & open competition, AETP can actually enhance long term competitions on programs and enable better technology insertion and/or requirements definition.

Whether AETP is ever fully implemented across the DOD, one lesson stands clear-acquisition reform and process change comes slowly! The entire bureaucracy must change paradigms and behavior before acquisition changes will be successfully implemented. Additionally, field experience shows that reform initiatives reduced to "guidance only" changes do not enable our DOD acquisition workforce to better serve the taxpayers. Whether Congressional, DOD, Service specific, or local reform **all initiatives must be carefully thought out** (with inputs from all levels affected) **and implemented** (adequate time to rewrite implementing regulations, conduct test cases, determine facilities & equipment needs, and develop training both specific and professional)-otherwise reform initiatives are doomed to fail.

SUMMARY OF AETP INITIATIVE

Background. Statutory language existed for almost 70 years at 10 U.S.C. 2274 and 9504.[2] FIG 1 reflects the statutory cites which have authorized non-competitive acquisition over the years. The 10 U.S.C 2274 and 9504 authority survived the 1984 CICA legislation although the non-competitive authority was rarely used. It appears that local commands were aware of the AETP statutory authority in 1986/87, but may have deemed it too politically sensitive (given the sweeping CICA legislation) to flow AETP down to the field. Little use was made of the authority until WPAFB personnel recognized that a serious gap exists throughout the AF in our ability to acquire hardware/software for small dollar one-time tests or experiments.

ASC Implementation of AETP. Local AETP policy was initiated at ASC, in late 1990 to implement the authority of 10 U.S.C. 2274 and 9504. After nearly two years of development and coordination an ASC policy letter, incorporating the AETP authority in the local ASC FAR Supplement, was issued in Nov. 1992. No other FAR, DFAR, Service specific, or local implementing language is known to exist for the AETP statutes. Use of the local AETP authority was complicated by several factors, and in FY 93 only one ASC acquisition successfully applied the AETP authority.[3] Once the language of the FY 94 Defense Authorization bill reached WP AFB and the much narrower language of 2373 was publicized, several acquisitions which had contemplated AETP authority were abandoned. Further, the local ASC policy was revised in June 1994 (to be in concert with the re-codified statute at 2373) to restrict use to only ordnance, signal, and chemical warfare supplies. For all practical purposes, AETP authority appeared

impotent for the vast majority of ASC programs which are aeronautical in nature.

Section 800 Report. An unexpected complication arose when the Section 800 Panel recommended deletion of the 2274 language and modification to the 9504 language only two months after ASC issued the local policy letter![4] Based on the Section 800 Panel recommendation, the FY 94 Defense Authorization Bill repealed sections 2274 and 9504 as "obsolete, redundant, or otherwise unnecessary", but reestablished narrower language at 10 U.S.C. 2373. The repeal and re-codification of the statutes has further inhibited use of the AETP authority.

Acquisition Reform. Fortunately, however, in mid-April 1994, the OSD Acquisition Reform Office, OSD(AR), contacted ASC personnel to inquire about the local AETP policy. Some field needs/issues hastily identified served as the focus of a brief meeting between OSD(AR) and SAF/AQ personnel wherein the AETP initiative was discussed.[5] Off line discussions between ASC and OSD(AR) personnel resulted in a request on April 18, 1994 for a detailed support package which could be used to help determine whether the AETP initiative should be included in the 1994 Acquisition Reform bill then in markup/conference in Congress. Inputs were received from twelve different organizations (within and outside ASC) and these were included verbatim in the package which was sent to OSD on 13 May 94. These inputs were utilized by OSD (AR) personnel who determined that the new 2373 language should be broadened to include aeronautical supplies as intended in the original 10 U.S.C. 2274 language. Such language was added to the FY 95 Defense Authorization bill in Aug. 94 to make the current statute coextensive in scope with the previously existing law. (See statutory language, Figure 2).

Need for AETP. Nine years have passed since Congress enacted the Competition in Contracting Act (CICA) legislation, and field acquisition personnel were tasked to ensure that all responsible sources are permitted to compete on non-exempted acquisitions over $25,000. The FAR Part 6 establishes the policies and procedures to promote full open competition in the acquisition process. CICA procedures require that sealed bids, competitive proposals, combination of competitive procedures, broad agency announcement, or GSA multiple award schedules be used UNLESS one of the seven statutory exemptions can be justified under 10 U.S.C. 2304:

(c)(1) - Only One Responsible Source
(c)(2) - Unusual & Compelling Urgency
(c)(3) -Industrial Mobilization or, Engineering, Developmental, or Research Capability
(c)(4) - International Agreement
(c)(5) - Authorized or Required by Statute
(c)(6) - National Security
(c)(7) - Public Interest

However, no authority exists which permits one time testing of: commercial products, new or emerging technologies, design improvements, etc. unless ALL responsible sources are permitted to compete. In actual practice, it is often found that on small dollar, one-time, test/experiment acquisition we can't write a strong enough Justification and Approval (J&A) to sustain an exemption. It would be a rare test process that could be justified as being a (c)(1) and performed by only one source. In the post-cold war era a (c)(2) urgency is more difficult to substantiate. Exemptions (c)(3), (4) and (5) are rarely used (certainly in

AETP applications). Exemption (c)(6) is occasionally not sustainable even if classified data is involved, and these authors have never seen (c)(7) used! AETP acquisitions do not require a J&A exemption in the ASC implementation which relies on a written Determination and Finding instead. What is needed is flexibility to go with a single or selected sources for one-time testing not a new CICA exemption since the acquisition or lease costs are usually small (between $50,000 and $500,000) and the test duration is usually short (from a few weeks to six or nine months).

Test data is often needed to make program decisions, resource allocations, refinements of requirements or specifications, validate compatibility with other existing and contemplated systems, or to evaluate a suggested improvement. CICA restrictions, while ensuring fair and equal opportunity to compete for federal acquisitions, also may inhibit DOD's ability to obtain timely data on commercial products, new and emerging technologies, manufacturer's design improvements for products already in DOD inventory, and urgent safety, life maintenance, and regional conflict issues (i.e. Desert Storm). Recent audit findings indicate decision makers did not have test results available prior to making the production decision on 42% of modification programs.[6]

Field Inputs on Need. Acquisition professionals are stymied by the acquisition bureaucracy and many recognize that acquisition streamlining for one-time test is sorely needed. We want to be able to acquire needed test data, identify the best hardware for our fighting troops, and integrate new technologies and commercial products into our aging weapons systems. Consider these words spoken by the program managers, engineers, and contracting officers who execute our acquisitions:

a. "AETP will enable us to exploit advancing technology in the commercial sector and quickly test it for application to DOD use. It will reduce the time and paperwork required for bringing a good idea into common practice. It will be endorsed even by the contractors who often become so bogged down in testing/experimentation stage that a good system dies before it can go to competitive bid. AETP will signal the Administration's intent to truly improve the acquisition process"[7]

b. "During a Component Technology Improvement Workshop, some manufacturers complain[ed] it was difficult, if not impossible, to introduce design improvements to their products once the configuration is delivered to DOD. The approach described above [AETP] would benefit both industry and DOD, and will allow the manufacturers to become knowledgeable of DOD requirements. This has the potential to further improve off-the-shelf components"[8].

c. "There was a specific case where the FACTS office attempted to lease three (3) communications test sets (radios). The procedures outlined in the local (ASC) AETP statutes were followed, but we were unable to obtain coordination from the Staff Judge Advocate's office. We were forced to place ourselves at the contractor's mercy by borrowing the test sets in exchange for the test results"[9]

d. "We are once again taking a giant step backward with the repeal of the AETP statutes. The (local) implementation of these statutes has been one of the very few significant acquisition reforms bestowed on

Contracting Officers. In most cases, COs are told to make something happen, and make it happen fast, well, and cheaply. Usually, we're left with whatever methods we personally have -- risky short cuts, personal charisma, and downright pleading -- to get the job done. AETP is different from most so-called reforms in that it actually changes the process rather than examining the number of steps in the process and how each small step can be accomplished or possibly even deleted. AETP is the first reform to look at the "big picture" and give COs the flexibility to work smarter"[10]

e. "Using AETP and my usual streamlining methods, I was able to shave at least two months off my lead-time, awarding it within a week of its critical date and thereby enabling my customer to meet a tight schedule"[11]

f. "One AETP [modification] was projected to cost less than $130K for one special type penetrator to be tested. The other AETP [modification] would have cost about $65K for a special type of penetrator. Now [that AETP statutes have been repealed] what do I do? Unless my program manager can rewrite his requirements, I do not see these actions as in scope. Nor do I see it possible to support a sole-source justification for either. Neither is it directly a matter of National Security. Urgency? We're not at war officially, so how can I justify urgency. The GAO told me a few years ago that urgency meant "the Russians are at the gate". Only One Source? Well, no. Although this particular ordnance reflects only a tiny sector of the Defense community, at least one other contractor could probably -- given enough hand holding -- do the work. So now I have to start from scratch and spend months, dragging both Government and contractor employees through a minuscule source selection for actions that could almost be done under small purchase procedures? No wonder the general public looks at Government spending with such disdain!"[12]

g. "It should be noted that many test and evaluation efforts do not involve major systems and high dollar funding (with the resultant visibility). Many more improvement and modernization programs could be based on simple solutions if acquisition authority existed to acquire items in a non-competitive mode. Without AETP authority, requirements personnel must "create" a situation where "Unusual and Compelling Urgency" is the basis for not competing or attempt to justify "Only One Source" with poor supporting data in order to procure items for test and evaluation when it is known that multiple approaches exist which could possibly meet AF minimum requirements"[13]

h. "During the past two years, modifications have become more difficult to accomplish due to approval process changes and reduced funding. The Competition in Contracting Act often adds to these frustrations by restricting access to existing and evolving technology. Both time and money can be saved with the effective use of the AETP authority by allowing access to existing technology. In many cases, costly and time-consuming development procedures can be eliminated by adapting existing technology to new requirements. Noncompetitive testing or experiment authority is needed to stimulate timely and affordable modifications that will improve safety, reliability and maintainability, and operational capabilities of our aging fleet of weapon systems."[14]

"SPIN-OFF" BENEFITS OF AETP

Other than the direct benefits of allowing our acquisition professionals to acquire needed test or experimentation data in a timely, resource favorable, and more cost effective manner, consider these other benefits of the AETP process.

Enhanced Competition & the PRDA. Consider the paradigm of competition that CICA has created in our process. Competition is **not** enhanced simply by allowing everyone to spend money on writing and submitting proposals which must be evaluated using carefully structured evaluation criteria. Look at the Program Research and Development Announcement (PRDA) process, actually a form of Broad Agency Announcement (BAA)[15]. The PRDA process has become an extremely popular method to stimulate creativity in R&D for military applications. The PRDA process publishes the solicitation in the Commerce Business Daily (CBD). Proposals are received and evaluated for general technical merit, but against top level assessment criteria. A technical assessment is made and the government may award any number of contracts, entire proposals or parts of proposals. Contracts are negotiated for selected technical proposals. Rarely are PRDA contract awards protested. The PRDA process actually enhances competition for later Dem-Val or EMD programs that utilize the PRDA developed technology. PRDAs are designed to maximize competition, primarily at the exploratory development stage.

PRDAs are also used in the System Program Office (SPO). The Advanced Strategic Tactical and Infrared Expendables (ASTE) program is one such ASC program which awarded five PRDA contracts in 1991, and now in 1995 is preparing to enter a Full & Open competition for EMD.[16]

AETP Process. Conceptually similar to the PRDA process, the AETP process deviates in several ways, yet enables the DOD to maximize corporate participation while maximizing flexibility to acquire limited one-time test or experiment. AETP acquisitions which exceed the small purchase limitation must be synopsized in the Commerce Business Daily (CBD).[17] The synopsis builds a minimum of six weeks into an acquisition cycle time, since two weeks are required to generate and publish the synopsis and 30 days is a statutory minimum response time. In times of national emergency or for other urgent acquisitions, or, for small purchase AETP acquisitions the need to synopsize might be waived. An AETP synopsis published in the CBD acknowledges the intent to look at a specified area for limited, one-time test or experiment and defines the Statement of Need for the testing, identification of the item or process to be tested, and method of test/experimentation believed necessary to accomplish the effort. Prior to publication of a synopsis the government already has identified a known group of potential offerors. However, other companies are free to respond and enter into dialog with the requirements personnel, and ultimately to submit a proposal that would be fully considered by the government. The government would perform a top level assessment (not as detailed as in a PRDA) and the requirements personnel would select the intended sources that would require the negotiation of awards. However, with AETP the test parameters have been generally defined and the assessments do not provide the basis for a competitive evaluation. The essential tenants of AETP are that 1) the government has an inherent right to obtain

test data 2) acquisition personnel are trained to determine the best acquisition strategy for one-time test/equipment; and 3) AETP acquisitions, when documented and synopsized, as required, are not protestable. A typical competitive acquisition rigidly defines the government needs by part number, in a Statement of Work or in an System Requirements Document. We tend to think that only by defining requirements can offerors propose, and the government competitively evaluate the proposals. AETP acquisitions would allow the government needed flexibility in a rapidly changing technological and fiscal environment to support EMD & production program requirements definition, and improvements to inventory items, to fill the "gaps" in IOT&E, safety, and urgently needed test data, (or even the evaluation of items produced by commercial /industry standards in lieu of MIL-SPEC/STDS)! The maximization of flexibility to chose differing test methods, items of test, etc. means competition may not exist across all proposals.

F-16 NVG CASE STUDY

The F-16 System Program Office (SPO) had been directed by a user through a Program Management Directive (PMD) to modify 200 aircraft with Night Vision Imaging System (NVIS) which would allow pilots to wear Night Vision Goggles (NVG) making the F-16 more combat effective and safer to fly at night. The SPO was to conduct Tactics Development and Evaluation (TD&E) testing with eight F-16 aircraft to evaluate the operational capability and suitability of NVG to provide F-16 pilots with enhanced night mission effectiveness. The testing had a fourfold objective: 1) evaluate the available NVGs; 2) determine the capability/suitability of NVG with cockpit lighting modifications; 3) determine the effectiveness of NVG compatible ground position marking devices; and 4) determine the capability of NVGs with LANTIRN. In late 1992 the SPO determined that the recently issued ASC policy on AETP provided the most economical use of SPO manpower and the optical acquisition strategy and technical payoff. Based on discussions with Night Vision Lighting (NVL) industry the SPO anticipated three or four AETP awards, each estimated to cost $100,000 or less, which would have allowed the NVL industry leaders to actually modify F-16 cockpits with their unique lighting schemes. The Air Force then would have flown the modified cockpits for 3-4 months of flight testing and AF pilots would evaluate the effectiveness of the different NVL on the flight instruments. Later the F-16 requirements personnel would have generated specifications for a follow-on competitive acquisition based on the preferred NVL technologies and which specified instrumentation must receive NVL. The F-16 Program Manager for the NVL program stated, "AETP would have allowed us to do the following: 1) Support the ACC testing requirement in a timely manner; 2) Evaluate four different approaches for NVL installation on the F-16 to determine the most cost effective modification; 3) Generate specifications for follow-on NVL procurements based on the best approaches from each of the contractors for various "zones" of the F-16 cockpit; 4) Provide cost estimates for submittal into the F-16 POM; 5) Determine the cost, schedule, and technical risks of a follow-on program; and 6) Avoid the pass-through costs associated with contracting with the prime (F-16) contractor."[18]

The F-16 was prevented from utilizing the AETP authority and finally went through another organization to utilize an existing

contract. All of this took 19 months, more money and produced less technically desirable results because the industry NVG houses were subcontractors to the prime. In March 94, a contractor submitted an unsolicited proposal to modify an F-16 cockpit with NVL at No Cost (which the SPO had to reject because it wasn't considered "innovative or unique" enough). The F-16 **again** attempted to utilize the AETP authority in March 94 only to find that the 1994 Defense Acquisition bill passed months earlier had repealed the statutory authority. The F-16 finally abandoned the effort, but their experience in frustration is not unique in the DOD.

Contracting Directly. One last thought on how AETP could improve the perceived competition we currently foster. Award of a task or delivery order or contract modification for a needed test or experiment may be possible within scope of a "competed" contract. However, such awards do nothing to enhance competition and are likely to cost more (than going direct to the technology house); produce a less optimal technical result, and take longer because of added layers of management. The AETP process allows the government to contract directly with industry for needed testing. It enables interested companies to dialog with the requirements personnel who are free to select those firms who offer unique solutions or test capabilities. It also probably means we can rely less on existing contract vehicles (i.e. task order or use of the "Changes" clause) to acquire testing.

Reduced Manpower Across DOD. As the draw down continues those remaining in acquisition know that our jobs have gotten harder. We have fewer personnel to accomplish a mission that involves more "false starts", funding delays, and what seems like more "political" impacts. We simply don't have the personnel to staff source selections. The "streamlined" Appendix BB of the AFFARS requires a Source Selection Authority (SSA) and Source Selection Evaluation Team for acquisitions over $5 million! An Appendix BB source selection typically uses 30-35 personnel working 9-12 months! An AETP acquisition (contractually less than $5M) could be accomplished with 4 or 5 personnel over 4 or 5 months.

Acquisition Reform. AETP authority conceivably could be used to "test" the implementation of Acquisition Reform across the DOD! Imagine a one-time test of several EDI systems that could meet the requirements of FACNET. Now that's using your AETP!

Technology Insertion.

AETP authority can be used to test the insertion of new technology into existing systems. This function is especially important where we are seeking to upgrade existing systems rather than develop new ones.

REMAINING EFFORT TO FULLY IMPLEMENT AETP

DFAR Guidance Needed. In Dec. 1994, the Acquisition Reform Office determined that the AETP Authority should be implemented DOD-wide. This decision resulted largely from the ASC inputs submitted on 13 May 1994. The DFAR language will be modeled after the ASC language and is likely to include guidance at Part 206 to clarify the non-competitive authority and at Part 217 to establish the special contracting methods used for AETP

acquisition. Significant work remains to develop the DFAR guidance and OSD(AR) intends to work to rapidly consider the four or five major implementation issues. We welcome your inputs on this implementation of AETP in the DFAR. It is anticipated that DFAR language will be available for public comment late-1995.

Command and Center Implementation. Once the DFAR and AFFAR language is implemented, it is important that Command FAR Supplements flow down the available statutory authority, otherwise Contracting Officers and Program Managers will not be empowered to actually use the authority.

CONCLUSION

Something must be done to allow the DOD greater flexibility to acquire the test or experimental data required to make the best decisions on our programs and acquisitions. One solution is to implement AETP language in the DFARS to ensure contracting officers and program managers have greater flexibility to conduct one time test or experiment to: a) conduct testing of commercial products or supplies to avoid unnecessary development costs, b) remove the hindrances (schedule, technical, and business) experienced under the Competition in Contracting Act (CICA), and c) foster more efficient use of acquisition manpower and taxpayer funds. Because of the procurement lead times and manpower restrictions, CICA requirements and other restrictions we force acquisition professionals to 1) modify requirements to accommodate available business strategy, 2) small purchases or imprest fund/credit cards are seen as the **only** avenue to acquire expeditious testing, 3) large support task and delivery ordering contracts are used routinely to acquire needed testing, 4) scope is stretched on existing contracts to acquire data produced by testing, **or** 5) needed testing goes undone. Reductions in acquisition personnel and budget inability to insert new/emerging technologies, empowerment of acquisition personnel, and even common sense tell us that we must facilitate the application of 10 U.S.C. 2373 authority to preserve the ability to conduct limited, one-time test/experiment when it is determined necessary.

Two years ago we concluded that the AETP statutes at 10 U.S.C. 2274 and 9504 held great promise of savings. In the name of acquisition streamlining these statutes were repealed and revised, respectively, in the 1994 DOD Defense Authorization bill! Due to quick work by the DOD Acquisition Reform office the 1995 Defense Authorization bill expanded the newly established authority at 10 U.S.C. 2373 to include aeronautical supplies. Will the system allow a paradigm shift on how we look at competition? Are the DOD policy makers in touch with the reality or of the field? The future of AETP will tell.

Pat and Terry would like to thank the contracting officers and program managers who provided inputs and especially Lorna Tedder, one gutsy and smart CO! This paper reflects the views of the authors and does not reflect the opinions of ASC or OSD (AR) as a whole. Contact Pat Krabacher ASC/LN at DSN 785-2425, or (513)255-2425, ext 3709 or FAX 476-4598 for additional information. Contact Terry Squillacote, OSD(AR) at (703) 614-3882 or Fax (703) 614-1690.

AETP Bibliography.

1. Conference Proceedings of 1993 Acquisition Research Symposium Proceedings, pages 433 through 441, "Acquisition for Experimental or Test Purposes", Patricia Lemmer and Lt Col Lester Katahara.

2. Statutory and legislative history document the need for non-competitive aircraft/parts/accessories the 1920's (Air Corps Act of 1926).

3. WL/PK letter of 6 Oct. 1993 (annual report of Noncompetitive Acquisition) for the Unitary Hard Target Penetrators, F08630-93-C-0054.

4. "Streamlining Defense Acquisition Laws", Report of the Acquisition Law Advisory panel to the Congress, Jan 1993, Chapter 3, pg. 3-387 quoted these statutes as being "obsolete provisions".

5. ASC/PK Memorandum for SAF/AQC, "Need for Non-Competitive Acquisition of Testing & Experiment" dated 15 Apr. 1994.

6. Report of Audit, Test and Evaluation Management of Aircraft Modification, Project 93063020, 31 Jan 94, pg.

7. DOD Air National Guard Input (Lt. Col. David A. Brubaker) to Support Package for Non - Competitive Testing/Experiment, 3 May 1994.

8. "(Facts) Input (Maj. Tonie Cosse) to support Package for Non - Competitive Testing/Experiment, 3 May 1994.

9. ibid.

10. Wright Laboratory/MNK Input (Ms. Lorna Tedder) to support Package for Non-Competitive Testing/Equipment, 26 Apr 1994.

11. ibid

12. ibid

13. 4950th Test Wing Input (Ms Caroline A. Pultz) to support package for Non-Competitive Testing /Experiment, 6 May 1994.

14. Tucson Air National Guard Input (Tom Crozier) to support package for Non-Competitive Testing/Experiment, May 1994.

15. The PRDA process is considered competitive and is described in the AFMC FARS at 5335.90. Further, the PRDA is an R&D application of the Broad Agency Announcement (BAA) described in the DFAR at 235.016.

16. ASC/LNW manages the ASTE program. Contact Jackie Owens, (513) 255-6004, ext 3654.

17. Synopsis of actions exceeding the small purchase limitation is required by 41 U.S.C. 416 and FAR 5.101.

18. F-16 SPO Input (Capt. Marlon G. Camacho) to support package for Non-Competitive Testing/Experiment, 10 May 94.

LEGISLATIVE
FLOW DIAGRAM
"Procurement for Experimental Purposes"

10 (k)
Air Corps Act of 1926
P.L. 69-446
(H.R. 10827)

o Aircraft
o Aircraft Parts
o Accessories

('39)

10 U.S.C. 310(k)
Purchases Abroad of designs, aircraft, etc. for experimental purposes: procurement in quantity

50 U.S.C. 96
(P.L. 76-178)
(S.1020)
Purchase of Equipment for Experimental and Test Purposes
- o Ordnance
- o Signal
- o Chemical Warfare

('56) CODIFICATION OF MILITARY LAWS

10 U.S.C. 2274
Procurement for Experimental Purposes *

10 U.S.C. 9504
Procurement for Experimental Purposes *

10 U.S.C. 2373
(P.L. 103-160, Sec 82)
Procurement for Experimental Purposes

10 U.S.C. 2372
( )
Procurement of Aeronautical Supplies for Experimental Purposes

FIGURE 1

2274. Procurement for experimental purposes.

(a) The Secretary of a military department may buy designs, aircraft, aircraft parts, and aeronautical accessories that he considers necessary for experimental purposes in the development of the best kinds of those items for the Army, Navy, Air Force, or Marine Corps, as the case may be. Purchases under this subsection may be made abroad or in the United States or the Territories, Commonwealths, and possessions, with or without competition and by contract or otherwise.

(b) If, as a result of a purchase under subsection (a), a new or suitable design considered to be the best kind for the Army, Navy, Air Force, or Marine Corps, as the case may be, is developed, the Secretary of the military department concerned may contract for procurement of the item in quantity. Contracts under this subsection are subject to sections 2272(f) and 2279 of this title but are not subject to sections 2271(a)-(d) and 2272(a) of this title.
(Aug 10, 1956, c. 1041, 70A Stat. 126.)

9504. Procurement for experimental purposes

The Secretary of the Air Force may buy ordnance, signal, and chemical warfare supplies, including parts and accessories, and designs thereof, that he considers necessary for experimental or test purposes in the development of the best supplies that are needed for the national defense. Purchases under this section may be made inside or outside the United States, with or without competitive bidding, and by contract or otherwise. Chapter 137 of this title applies when such purchases are made in quantity. Aug. 10, 1956, c. 1041, 70A Stat. 575.

PUBLIC LAW 103-160, SECTION 822 10 U.S.C. 2373

(a) AUTHORITY. The Secretary of Defense and the Secretaries of the military departments may each buy ordnance, signal, chemical activity and aeronautical supplies, including parts and accessories, and designs thereof, that the Secretary of Defense or the Secretary concerned considers necessary for experimental or test purposes in the development of the best supplies that are needed for the national defense.

(b) PROCEDURES. Purchases under this section may be made inside or outside the United States and by contract or otherwise. Chapter 137 of this title applies when such purchases are made in quantity.

AETP Figure 2

JOBS IN THE WOODS

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ABSTRACT

In the Spring of 1993, President Clinton held a conference in Portland, Oregon in an attempt to resolve the disputes and tension between the timber industry, environmental groups, and concerned citizens. The focal point of the discussion involved the habitat for the Northern Spotted Owl. The larger issue was the use of public lands, particularly those remaining that were largely undeveloped and still covered with old growth timber. Of particular concern was the impact on logging dependent communities as National Forest holdings became increasingly unavailable for harvesting timber. These issues have long been politically sensitive and disputes of this nature have existed as long as the Federal Government has been involved in land use policy. However, the drastic change taking place was eliminating the jobs of many people.

The 1994 Appropriations Act for the Forest Service [1] contained funding for watershed improvement in the Pacific Northwest. The impacted areas were forested areas in Northern California, and the states of Oregon and Washington. Although nothing in the legislation addressed procurement law, the Conference Report discussed intent to spend money for Community Assistance. To meet this intent, Secretary of Agriculture Mike Espy, signed a Determination and Finding invoking exception 7 to the Competition in Contracting Act (41 USC 253). This essentially freed the Forest Service from Competition in Contracting Act constraints. This paper describes the rules developed for selecting competing firms and elaborates on how this program functioned during its first year of application. Primary issues involved included how to develop a program that limited contracts to firms located in specific geographic areas, whether there should be attempts to limit workers to residents of those communities, how to accomplish outreach within the restricted area, and how to provide assistance to new firms established by displaced workers. The basic problem was how to put a program in place that in many ways was foreign to fundamental ideas in Government procurement. This paper will also discuss some long term ramifications of approaches such as aiding communities affected by political actions set in motion by the changing desires of the American Public.

INTRODUCTION

The United States Forest Service was established early this century as a major land manager for the United States Government. The Forest Service manages 191 million acres of forests and grasslands. The Bureau of Land Management manages a huge portion of the United States range land. In places, the land types are difficult to distinguish but a good rule of thumb is that the Forest Service manages forested areas and the Bureau of Land Management manages areas of rangeland. The National Park Service, of course, manages the national parks. Although the areas that the Park Service manages are quite diverse (the Washington Mall to Yellowstone and Glacier National Parks) their

Please note that the views expressed in this paper are those of the author and do not necessarily represent the views of the Forest Service or the Department of Agriculture.

role is much clearer. They have the role of preserving national and historic treasures and providing recreation for the American Public. (They might define it differently but you get the point.) On the other hand, the Forest Service and the Bureau of Land Management have always had the competing concerns of both using the resources on the land they manage while preserving and protecting the resource. The Bureau of Land Management has at least two areas of critical extractive use management in grazing and mining. This paper is not about that either. The land management agencies have always been torn by two competing interests that tend to be mutually exclusive. In the early part of this century, John Muir, who believed that the public lands should be kept as close as possible to their pristine state for the enjoyment of citizens who wanted an outdoor experience, represented one side of the equation. There is a great deal of written material concerning the benefit that people derive from "having" a wilderness experience or simply knowing that it is there to experience if one wished to do so.

On the other hand, Theodore Roosevelt and Gifford Pinchot, the first Chief of the Forest Service, believed in the multiple use philosophy. They believed that it is possible to extract resources in a careful way and still preserve recreational and other somewhat non-extractive benefits. This position is summarized in the short statement of "Multiple Use, Sustained Yield."

The tension between these two points of view has never been resolved. This can be seen through the continuing tension between the timber, mining, ranching, fishing, and other extractive interests and groups such as the Audubon Society, the Sierra Club, and, at the extreme, the Friends of the Earth. The Forest Service attempts to manage the land in a way to best meet the needs of the nation and be sensitive to both these concerns. The motto or mission of the Forest Service is expressed in "Caring for the Land and Serving People."[2]

Although, depending on your point of view, the United States Forest Service may be wearing a white hat or a black hat, some of its missions have been non-controversial and others have caused more problems. For example, land managed in the Northeastern part of the United States includes major areas trashed by original users who logged, mined, or farmed, the land to exhaustion. The Forest Service was assigned responsibility for these lands and restored them to attractive and useful areas. Not too much to complain about in this situation other than the question of "is this the proper role of the federal government" that some might ask. The lands managed in the South also do not present as many difficulties. Much of this area has been inhabited for many years and several crops of timber have been harvested. The West was another story.

Originally, the West was settled and/or exploited by people who saw incredible wealth and extensive resources before them. The mountainous forested areas were vast and seemed to be inexhaustible. The Forest Service was charged with carefully looking at this vast resource for which they were responsible and identifying appropriate uses for it. The Agency identified some areas as useful for logging and reforestation; some for hunting; some for camping and hiking; and some for wildlife. These missions tended to be isolated and specialists grew up around them. So did constituencies. Hunters wanted wildlife and roads. Wilderness lovers wanted places they could go and not hear traffic, guns, motorcycles, chainsaws, or see very many people. Major battles took place in Congress

over how these uses should be allocated and supported.

Meanwhile, the chainsaws inexorably reduced the amount of virgin timber in the west including cutting their way through huge stands of very old majestic trees. Forest Service managers looked at these stands of trees as crops and thought and talked of 90 and 100 year rotation cycles. Preservationists looked at the majesty of these trees and their own finite existence and that of their children and thought "I do not want these trees cut down."

The dispute between the extraction oriented citizens and the preservation oriented citizens placed Forest Service land managers in an awkward situation. Forest Service planners worked hard to please everyone. They failed. The battles not only took place in Congress but also in the forests where people chained themselves to equipment and trees, drove huge spikes into logs that can and did kill when struck by rapidly spinning chains on saws or circular saws in processing mills. The battles took place in the courts where every aspect of Forest Plans was challenged on the basis of any deficiency, actual or perceived, which a legal mind was willing to argue.

At present, the Forest Service is undergoing basic structural reorganization but its current structure includes a segment that manages the land it oversees; an arm that conducts research not only on basic issues concerning plants and animals but also use of forest resources; another arm is concerned about working with states, other governmental entities, and private citizens; and the newest arm is concerned with international and global forestry issues.

Acquisition through the procurement process has always been an important way to support these efforts. Besides what is needed to support the organization, the Forest Service has traditionally spent its major sums of money on road construction, reforestation, and more recently has begun to work on remediation of environmental problems.

All of which brings us to a small bird: the Northern Spotted Owl. This paper is not concerned about, nor will it address, the merits of the scientific argument about the Northern Spotted Owl other than to note that the Owl was alleged to be in danger of extinction because of the loss of its habitat that were the large tree old growth forests that were being reduced fairly rapidly. The Forest Service multiple use position was that adequate land had been set aside for wilderness and that only reasonable areas were set aside for timber harvesting. The opponents argued that prime, pristine, old growth was being destroyed at a rapid rate and that the owl was scheduled for extinction with the trees. During the 1980's the timber industry had grown considerably in the rural areas of Oregon, Washington, and Northern California where this battle was being played out. By the early 1990's the situation had deteriorated to one where the courts were deciding almost on a case by case basis which timber harvesting projects were going to go forward in this area. The changes were profound. For example, in the impacted area, the timber harvest in the 1980s was about four billion six hundred million board feet per year. This was reduced to approximately two billion four hundred million board feet in the 1990-1992 period and was projected at only one billion two hundred million for 1994. [3] This is a reduction of almost 75% from what the industry in this area had come to expect. This is in a rural part of the country where most of the work force either worked directly on harvesting or processing the wood in mills or provided the necessary community support. To say that this was a major impact on the

economics of this part of the world would be a serious understatement.

INTERVENTION

On April 2, 1993, the President convened a Forest Summit Conference in an attempt to find solutions to the very difficult problem of providing adequate protection to a threatened bird and assisting communities where that protection was causing grievous economic harm. Besides the President, the Vice-President was there as were the Secretaries of Agriculture (Mike Espy) and Interior (Bruce Babbitt). Members of Congress and many concerned local citizens were also there, of course. This meeting resulted in the creation of a Memorandum of Understanding signed by the President, Congressional Representatives, and other concerned parties. The basic intent of this Memorandum of Understanding was to increase economic activity in the affected communities to make up for the economic loss caused by the decline in the timber harvest.

After the Conference, two actions began. One of these was national and the other was local. Congress provided funds to accomplish the goals of the agreement and a structure of community based organizations were established and began working to decide what needed to be done. The local teams went under the general title of "Community Economic Revitalization Teams" (CERT) and there was an organizational system of CERTs created. Their function was to determine local needs and coordinate with Federal Agencies to see that those needs were met. These groups were created in November of 1993 and were organized by state and region. There was a multi-agency command for this structure established in Washington, D.C. The Governors of California, Oregon, and Washington as well as the Chair of the Multi-Agency command signed the final plan for the Community Economic Revitalization Teams in December of 1993. There was a major issue in working with these groups about the Federal Advisory and Committee Act. It was resolved and is not the topic of this paper other than to note that trying to involve local communities in Federal efforts often has unanticipated consequences.

The national issue was providing funding and a mechanism for spending the money. This was a major initiative involving many federal agencies. Contract expenditures were but a small portion of the $300,000,000 available for this project. Congress provided well over half of these funds to the Department of Agriculture's Rural Development Administration. The funds for the Jobs in the Woods program for the Forest Service was around $20,000,000 or just less than 7% of the total expenditure. In addition, the Bureau of Land Management was to spend $5,000,000 and the Fish and Wildlife Service and the Bureau of Indian Affairs $1,000,000 each. This total of $27,000,000 then was just under 10 percent of the total program. Besides the agencies already cited, funds for the program were provided through Housing and Urban Development, the Small Business Administration (loan guarantees only), the Department of Labor (Title III money for the Job Training Partnership Act), the Department of Commerce, and the Environmental Protection Agency. [4]

<u>Acquisition Issues:</u> In late 1993, the procurement mission began. The initial Forest Service mission was to support local communities by contracting for watershed restoration services in the amount of $20,000,000 to help communities in the coastal mountain ranges from the Canadian border into Northern California by the end of fiscal year 1994. The individual communities were expecting that the money would be spent

locally. They were expecting that the contractors would be local and that the workers will be local. They expected that the money would be flowing very quickly since they needed it immediately. Clearly smaller projects would not be a problem. Acquisitions of less than $25,000 could be obtained with limited local competition and a reasonable expectation that the workers would be of local origin. Larger acquisitions presented more difficulty.

There were really two major issues here: who the contractors might be and where would the workers come from. The two extremes of the argument were that the workers should not only all be local but also displaced timber workers and that contractors should all be local to insure that the money would stay in the community. The other extreme was that the Competition in Contracting Act required national advertisement of formal procurement with no restriction on the workers other than that they be legal.

The issue of the workers was fairly easily resolved. There was some strong sentiment for guaranteeing that the work force would be displaced timber workers. However, that argument failed because any mechanism to attempt to insure this would either collapse of its own weight or be excessively burdensome. The skill mix was not always good. Sawyers and mill workers were not always willing to become laborers on construction and other watershed restoration projects. Therefore, the concept of trying to develop a system to target who could be hired on these projects was abandoned.

The issue concerning the geographic qualification of the contractors needed more careful attention. The Forest Service was used to limiting competition under the Competition in Contracting Act when the situation was urgent and time did not permit full and open competition. There were advocates for using this authority in this situation. However, the argument prevailed that although this was a difficult situation for many U.S. Citizens in one part of the country, there was no serious threat to the nation or to the lives of its citizens. Arguments that there were only one or a few sources that could do the work were patently untrue so that did not merit a great deal of consideration. No serious thought was given to arguing that there was a need to maintain any particular industrial base as a way to limit competition. This left exception 7 to the Competition in Contracting Act -- the Public Interest Waiver. It made a great deal of sense and seemed to fit the situation very well but using it had several serious drawbacks. First, it required Secretarial approval and was something that had rarely been used. Its few occasions of use had been accompanied by problems. Second, it required Congressional notification with thirty days of waiting before beginning work after that took place. Third, it required this approval to be done on a specific project basis. Although the authority fit the situation very well, it was easy to guess that this situation was not quite what the drafters of the law had in mind. Most likely it was intended for a situation where it was in the national interest to award a contract to a specific vendor when the need for an industrial base could not be justified but it would be in some unspecified way in the national interest to take that act.

Exception 7: After a great deal of internal debate and discussions between procurement personnel at field locations and the Washington Office of the Forest Service, Department of Agriculture General Counsel personnel, and the project managers, it was decided to seek Secretarial approval for an exception to CICA based on national interest. This was not taken lightly but there was good

expectation of approval since the Secretary had been party to the original Memorandum of Understanding so was aware of and interested in the project. Also, Secretary Mike Espy had taken an uncommon interest in the subject of procurement as shown by his calling most of his assistant Secretary's together in a meeting room with most of Department's procurement personnel in the Washington, D.C. area and declaring his interest in procurement and then convening a task force to improve Departmental procurement.

However, the issue was not clear cut. What action to take and exactly how to take it involved many discussions and memos between local managers, national project managers, Departmental attorneys, and the procurement management community. Finally in April of 1994, the Chief of the Forest Service brought the recommendation to a head when, in a letter to the Secretary, he stated:

> I have determined that it would be more appropriate to recommend to the Secretary of Agriculture to seek a public interest waiver for these projects pursuant to 41 U.S.C. (paragraph) 253(c)(7). A public interest waiver offers the most flexible means of accomplishing the direction laid down by President Clinton and Congress to direct award of these watershed restoration projects to communities affected by decreased timber harvesting. [5]

Clearly we could not have the Secretary individually approve each of the hundreds of projects that the Agency intended to accomplish. Therefore, the Agency decided to obtain the listing of all the projects that were to be accomplished. Although the Revitalization Teams had been working with the local procuring units, the specific projects were far from being ready for clear identification. Since the work field season was rapidly evaporating and the Secretarial approval and Congressional notice had yet to be accomplished it was vital that the projects be identified and provided to the Washington Office of the Forest Service for consolidation and submittal to the Department of the Agriculture. Although this was a difficult task, it is not particularly instructive here except to note that in situations like this it is useful to stay flexible and keep a sense of humor.

On April 11, 1994, the Secretary of Agriculture approved the request from the Forest Service and the necessary notification was hand carried to the Speaker of the House of Representatives and the President of the Senate.

<u>Freefall:</u> Oops. It quickly became apparent that taking exception to the Competition in Contracting Act meant that major requirements of the Federal Acquisition Regulations had just disappeared with no good precedent on how to proceed. This was both liberating and somewhat daunting. The concerns came from having to insure that business would be accomplished properly in an uncertain environment. The liberating feeling came from knowing that it was now possible to take the best possible actions to meet the intent of those that had provided the funds while still maintaining the integrity of the procurement process. The Forest Service has long maintained that the keys to the federal acquisition system are fairness and flexibility. The Agency now had the opportunity to prove that it could operate in

this fashion.

As discussed above, the Agency had dropped the idea of trying to limit who was eligible to be hired by contractors but still needed to decide who could compete for these projects. There was no sentiment for including contractors that were not near the impacted area. There would have been little reason for the exception if competition had been open to all. The only reason would have been time and although that was significant it was only one small part of the need. The three major alternatives were to contract with: 1) firms located in the general area of impact; 2) firms located only in the impacted counties; and 3) firms locate in the county where each specific project was to be accomplished.

1. Although the areas of greatest impact were clearly identified, the entire area was hurt by the reduction in timber harvesting and processing. Also, although workers do travel great distances to accomplish Forest Service contracts, most of the contractors work in a general localized area and it might be difficult to explain to contractors in Eastern Oregon why they could not compete for contracts where they normally did. The exclusion could be more easily justified to a contractor who lived in some Southeastern state, for example.

2. The Agency did have the advantage of having a clearly defined area of affected counties. Making the assumption that all contractors residing in any of these counties in the three state area could compete for the work permitted maximum competition in the impacted area. This general impact is important since one facet of this evaluation was that there was not necessarily a connection between where the projects were located and where the nearest communities were. For example, if the work were to be accomplished in a forested area close to a community, the community clearly would have a major interest in having the work accomplished by local displaced contractors and workers. On the other hand, there were situations where the work was to be accomplished in forested areas where there were no or few contractors or residents. In this situation, more latitude needed to be taken.

3. The most restrictive approach would be to limit the contractor base to the local community or county and not allow outside contractors to compete. This was in some ways most attractive to some local communities and Revitalization Teams. If this were done, dollars spent in the local community would stay in the local community. There was strong feeling that this was what was intended and what should be done. It had the disadvantages identified

above of not always having a nice fit with where the work was to be accomplished and where the displaced workers might live. It also had the major disadvantage of needing to draft very specific contract language for each project and each community.

One Forest Service issue was to decide which of these three approaches to choose or to decide if there were other more attractive alternatives. It was clearly the intent of the legislation to direct funds to the local affected communities. Clearly the intent of Federal Procurement is to maximize competition in every situation. The Forest Service chose the second option described above of restricting competition to firms located within the affected counties but allowing any firms within the affected area to compete. [6]

Operations: Because the project lists were provided to Congress, every project was identified and known to interested Members of Congress and anyone else who was interested. Contracting Officers posted this list of projects in contracting offices throughout the three state area. However, contracting officers were free to, and did, concentrate on obtaining competition only from local contractors. If other firms in impacted portions of the three state area requested the opportunity to compete on any specific package, their proposals were accepted and evaluated. In a sense, these procurements were handled much like small purchases. Contracting Officers solicited Competition within local trade areas but accepted proposals from any interested proposer.

CONCLUSIONS

Although the procurement system takes many lumps it does work very well and has been designed to provide a great deal of flexibility to those who are willing to work with it. There seems to be at least two different procurement systems. The one is the legal requirement involving entering into, administering, and closing contracts. That system can, and usually does, work very well. The frequently maligned system is one where everyone from Congress and the President down to the local manager try to use it for their own purposes. For example, almost everyone who works with the system is aware of national impositions such as setting minimum wages for those employed on contracts to trying to increase the soundness of the system through the strictures of the Procurement Integrity Act. Systems are in place to insure that a fair proportion of business is provided to the small business community and even more specifically to disadvantaged firms and others specifically targeted. At the local level in small communities, a dwindling number, hopefully, of benighted managers prefer to have maximum flexibility in the placement of small purchases so they can guarantee that troubled local businesses survive and that no one unduly prospers from the federal procurement process. At its best, this may be understandable, if patriarchal. At its worst, it creates a power position for the local federal government manager that could lend itself to abusive control. ("It would be a shame Henry if you took that position. It would certainly damage us. Oh, by the way, how much business did we do in your store last year. You know, one nice thing about the small purchase system is that we have a great deal of flexibility concerning the vendors that we patronize.") The point is a simple one. The procurement system as practiced by

procurement professionals can work very well. In fairness, we can sometimes gum it up. However, THE PROCUREMENT SYSTEM as defined by everything that touches procurement (management, personal, and economic interests) from requirement initiation to final payment can have many problems from dealing with people who develop over controlling specifications, working through massive controls to insure that business is equitably distributed, and finally to fending off those that want to have the work accomplished by some specific individual or firm. In the Jobs in the Woods example, there was clear Congressional intent to support local communities affected by severe cutbacks in the logging industry. As is so often the case, that intent was not complete with the necessary changes in procurement legislation to make that work smoothly. However, the procurement system still has all the necessary tools so that even in these circumstances the system can work well.

Congress clearly intended and the Administration wanted to help through the procurement process a large number of communities that had been negatively affected by the reduction of timber harvesting because of environmental concerns. Although the Competition in Contracting Act requires maximizing competition it provides many situations where some liberties can be taken with the overall principle. This acquisition demonstrates that if an Agency is committed to a program it deems to be in the public interest, the procurement process does not have to be a barrier to accomplishing those objectives.

A standard accusation against the procurement system is that it takes too long. Sadly, that is often true. However, as discussed above, that is more the fault of the PROCUREMENT SYSTEM than it is of the procurement system. In this example, in less than a year large numbers of projects were identified; discussions were held with large numbers of local communities concerning what work would be of the most interest and value to them; a Secretarial waiver was obtained by two major civilian agencies; Congress was advised as required; projects were advertised and solicitations issued; contracts were awarded and work was begun; and, in some cases, completed. There is no question but what those involved in this process would have liked more time for reflection and review of this process. However, that time was not available the tasks were all accomplished within the allotted time. (Could Mr. Parkinson have been on to something?)

Interestingly, in light of our discussion of the problems of the larger or the smaller portions of the procurement system, one of the biggest difficulties was defining what tasks were to be done. Forest Service managers, like many others, are excellent at planning what will be done over the next 80-year timber cycle but not so good at planning what procurement will be done during the next fiscal year(or even in the current fiscal year). One thing that was clear early in this process was that the Agency could not expect to go repeatedly to the Secretary of Agriculture for his approval. Exception 7 to the Competition in Contracting Act does require case by case approval. Therefore, the Forest Service needed to identify all the projects that it intended to accomplish through the Jobs in the Woods program during Fiscal Year 1994. Although this could be perceived as a problem in the procurement system it would be as easy to think of it as a problem in knowing what the Agency really intended to accomplish. This process is again being conducted for Fiscal Year 1995 as this paper is being written.

The Jobs in the Woods program did a good job of expending the funds set aside. Although the Forest Service spent the most money, on a percentage basis its results were not as good as the other Agencies. The Bureau of Land Management obligated the $5,000,000 that was available to it and Bureau of Indian Affairs and the Fish and Wildlife Service each obligated the $1,000,000 available to them. However, the Forest Service was only able to obligate $11,284,000 of the $20,000,000 available to it. [7] This was due in part to the larger size of the program but more specifically to the horrendous fire season experienced during the summer and fall of 1994. Most Forest Service contracting resources were totally absorbed in providing fire support and the Jobs in the Woods program as well as everything else had to wait.

There was one very negative aspect to this otherwise successful program. Procurement targeted to specific communities provides a new opportunity for "pork barrel" politics. Traditionally, "pork barrel" politics has involved grants to specific institutions or firms or even money for a specific project in a geographic location. However, in most of these instances there has been no attempt to insure that the citizens of the area were the only ones that could bid or work on the project. [8] I think there is a general understanding that large companies have sometimes spread subcontracts widely across the country insuring that major portions would be in key Congressional districts. This normally tended to be covert as opposed to overt. The firms, at least in public, did not say their weapons system should be selected, not because it was the best, but because the major subcontracts were in key Congressional districts. Jobs in the Woods effectively defined a geographic area of concern and said only contractors located within this area can compete. This could be a major precedent in the base closure arena for the Department of Defense. To date the Secretary of Defense has not chosen to set aside procurement for Los Angeles or any other area because of the negative impact of base closures or reductions in expenditures in a specific geographic area. The Jobs in the Woods program set aside a rural portion of the country and closed certain contracts in that geographic area to most of the contractors in this country. This could have serious implications for rural legislators. If procurement dollars start being allocated by geographic area this will greatly complicate the process and the American people will be the losers in two major ways: Competition will be greatly reduced and opportunity for mobile contractors will similarly be reduced. This is not a concern for most of the people involved. For example, the Vice-President promoted this approach as a good way to do business: "This is the kind of interagency, intergovernmental cooperation I like to see . . . . We are part of the successful development of rural America here that other distressed communities can look to as an example of how to get things done." [9]

ENDNOTES

1. Public Law 103-138, Department of Interior and Related Agencies Appropriations Act.

2. Forest Service Motto shown as footer on all official Forest Service Correspondence.

3. "The Forest Plan, In Brief," Summary prepared for Interagency meeting, October 20 and 21, 1993, Portland Hilton, Portland, Oregon.

4. "Economic Adjustment Initiative . . . under President Clinton's Forest Plan," Annual Report, October 20, 1994, pp. 5-9.

5. Thomas, Jack Ward, Chief of Forest Service letter to Regional Foresters of the Pacific Northwest and Pacific Southwest Regions, Reply to 2520, Public Interest Waiver for Watershed Restoration Projects, April 4, 1994.

6. Reimers, Mark A. (for Chief of Forest Service) letter to Regional Foresters of the Pacific Northwest and Pacific Southwest Regions, Reply to 6300, Authority to Limit Competition, May 18, 1994.

7. "Economic Adjustment Initiative . . . under President Clinton's Forest Plan," Annual Report, October 20, 1994, p. A2.

8. This discussion on limiting work to local areas is of current interest in light of renewed interest in reviewing the Davis Bacon Act. It has been argued that the Act's original premise was to discourage the importation of cheaper labor from other parts of the country to the industrialized cities of the North. This then reflects a long time interest in keeping dollars in the pockets of local labor.

9. "Economic Adjustment Initiative . . . under President Clinton's Forest Plan," Annual Report, October 20, 1994, p. 5.

INTERNATIONAL ACQUISITION ISSUES

International Cooperative Acquisition Projects With Pacific Rim Nations

by

Richard Kwatnoski

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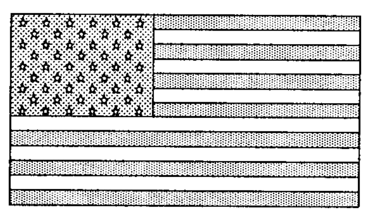

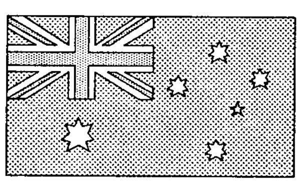

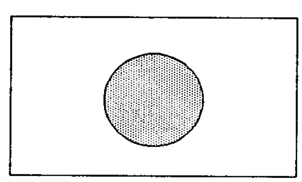

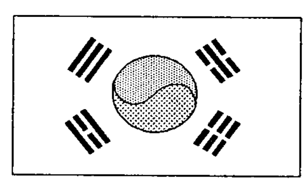

Defense Systems Management College

February 1995

Cooperative Acquisition Projects in the Pacific Rim

BACKGROUND

In 1992 the Defense Systems Management College (DSMC) began a study of international cooperative defense acquisition projects with the United States and countries in the Pacific Rim. This was the third of three related research studies of cooperative acquisition projects conducted during the past ten years. The first and second were studies of US/NATO-Europe projects completed in 1985[1] and 1990[2]. Responding to increasing student demand for information on PACRIM projects, DSMC took the lead for the third research study.

The research objectives were as follows:

- Describe the current reality of cooperative projects in the Pacific Rim.
- Determine the Rx, or prescription, for success by identifying barriers to and facilitators of cooperation.
- Examine similarities and differences between PACRIM and NATO-Europe Projects.

The PACRIM study progressed in four phases employing the tailored questionnaires and methodology developed during the two previous studies. The four phases are shown in Table 1.

Study Phases	Participating Organizations
I. Establish terms of reference and notes on cooperation	Office of Secretary of Defense, Defense Security Assistance Agency, and Service Staffs
II. Notes on cooperation	Allies - Embassies
III. International Acquisition Topics	U.S. Project Offices
IV. International Acquistion Topics	Allies Project Offices and U.S. In-Country Personnel

Table 1. Study Phases and Participating Organizations

Phase I was conducted to identify the PACRIM countries and projects of interest. As a result, the scope of the study was narrowed to include only the nations of

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1 C. Michael Farr, "An Investigation of Issues Related to Success or Failure in the Management of International Cooperative Projects," Ph.D. diss., University of North Carolina, Chapel Hill, 1985.

2 C. Michael Farr, "Managing International Cooperative Projects: "Rx for Success," Chapter 6, Global Arms Production, University Press of America, Inc., Lanham, MD, 1992.

Australia, Japan, and South Korea.[3] While others were mentioned, it is with only these three that the Department of Defense has the legal authority to enter into a cooperative acquisition. A cooperative acquisition must be jointly managed and equitably (or equally) funded by the participating nations, and there must be an international agreement setting forth the terms and conditions of the project. This is normally called a Memorandum of Understanding or Agreement (MOU or MOA). All international projects with any other PACRIM nation, cooperative or otherwise, must use Foreign Military Sales (FMS) procedures. The projects identified for study are shown in Table 2. A good balance was attained with at least two projects from each Military Department (plus one Defense Agency project), and at least two from each nation of interest.

[3] The nations are listed in alphabetical order; no precedence is implied. While Canada could be considered as a PACRIM country, it is normally included with the NATO-Europe countries.

The Projects Studied

Project	Military Department or Defense Agency	Allied Nation
Next Generation Support Fighter (aka FS-X)	Air Force	Japan
Ducted Rocket Engine	Army	Japan
Coastal Harbor Defense	Navy	South Korea
Ammunition Storage Technology	Army	South Korea
Digital Chart of the World	Defense Mapping Agency	Australia
Radar Activities	Air Force/Navy	Australia
MK-53 Off-Board Active Decoy (aka Nulka)	Navy	Australia

Table 2.

Phases I and phase II of the study were combined to produce general and country-specific notes on cooperation. These are covered in the next section.

Phase III conducted during 1993 and Phase IV conducted during 1994 focused specifically on the PACRIM projects. Interviews were conducted with both U.S. and allied in-country representatives of each of the project offices. Logistical support for the trip and additional information on the projects was provided by U.S. in-country personnel from the Joint U.S. Military Advisory Group (JUSMAG) in Seoul, South Korea, the Mutual Defense Assistance Office (MDAO) in Toyko, Japan, and the Office of Defense Cooperation (ODC) in Canberra, Australia. The allied project offices visited are shown

at Table 3. These included the Agency for Defense Development (ADD) laboratories in Chinhae and Taejon, South Korea; the Technical Research and Development Institute (TRDI) in Toyko, Japan; and the Jindalee Operational Radar Network (JORN) Program Management Office, the Nulka Project Office, and the Director of Survey - Army in Canberra, Australia. Since the detailed questionnaires provided to both U.S. and allied project offices were identical, and the questionnaires were similar to those of the U.S./NATO-Europe project studies, comparisons between U.S. and allied views on cooperative acquisition can be made, as well as some general comparisons between PACRIM and NATO projects.

Project Organizations Visited

Project	U.S. Organization	Allied Org
Coastal Harbor Def. Ammo Storage Tech	NRL, Washington, D.C. TCES, Savanna, IL Support: JUSMAG-K	ADD, Chinhae ADD, Taejon
FS-X Ducted Rocket Engine	F-16 SPO, WPAFB, OH MICOM, Huntsville, AL Support: MDAO	TRDI, Tokyo TRDI, Tokyo
Radar Activities Nulka Digital Chart of the World	ESC, Hanscom AFB, MA TAD PEO, Crystal City, VA DMA, Fairfax, VA Support: ODC	JORN PMO, Canberra Nulka PO, Canberra Dir. of Survey - Army, Canberra

Table 3.

One of the great difficulties in a study of the Rx for project success is in determining the definition of success. Early on in the study a simple definition was developed. Success was defined as having a signed MOU, national funding provided from the participating nations, the project initiated, and no withdrawal or termination due to unresolved problems. All the projects studied met this definition at both the beginning and end of the study. The simple definition and the nature of the projects available for study, for the most part, led to a focus on the very preliminary stage of the acquisition process.

NOTES ON COOPERATION

General

The first and foremost general note that must be kept in mind is that there is no equivalent to NATO in the Pacific Rim. This means that there is none of the vast NATO-type infrastructure in place to support cooperative activities with Pacific Rim nations. Therefore, with few exceptions,[4] our cooperative acquisition projects with Australia, Japan and South Korea are conducted bilaterally, and will remain so for the foreseeable future. The U.S. enjoys favorable defense trade balances with the three nations, and is therefore pressured to give generous terms in cooperation. Furthermore, one should not be fooled into stereotypical thinking. Each nation is different -- Japan is not like Korea; Australia is different in many ways from the U.S. There can be enormous cultural differences between each nation as well as management styles and motivations for cooperative acquisition. One also should beware of "European Strings," which may tie our hands in the Pacific Rim because of prior commitments made in European projects. Interestingly, there was

[4] The exception is Australia, which participates both bilaterally and multilaterally with the U.S., United Kingdom, Canada, and New Zealand.

a perception among the U.S. staff personnel interviewed that our system was the most problematic when it comes to cooperative acquisition. This was especially pronounced in our legal system (eg. treatment of intellectual property rights) and acquisition system (eg. competition policies).

Australia

Australia is geographically a Pacific Rim nation, but is heavily populated with transplanted Europeans. For the U.S., Australia is culturally the easiest nation to work with in the Pacific Rim, if not in the world. Further smoothing relations, Australia is not viewed as a competitor to the United States, whether economically or in the defense export market. The Australian defense budget is very small in comparison with that of the U.S., but they maintain a relatively large portion for research. Therefore, Australia can be viewed as strong on research, but weaker on development. They seek more cooperative projects with the U.S. to develop outlets for their research technology, and to attain rational production quantities. Their rationale for cooperation is to access technology, promote their technology, realize economics of scale, promote interoperability, and encourage industrial participation with "residual" capability. All, except the last, are identical to U.S. motivations for cooperation. Residual capability refers to an Australian motivation to further build their industrial base, and to examine every potential cooperative project for the industrial capability retained in Australia after project completion.

Australia explores cooperative project opportunities through a variety of ways. These include the structural process (attaches, exchange officers, etc.), multilateral forums (ABCA, TTCP, 5 Nations, etc.), senior national representative meetings, and project teams specially formed to examine the pros and cons of the cooperative project.

Australia cooperates with many nations beside the U.S. They cooperate with New Zealand to attain rational production quantities for many types of defense material, and the United Kingdom, primarily on naval projects. Australia desires to strengthen local ties. There have been successes in joint exercises, logistics, and sales, but no armaments cooperation as of this writing.

Australians cite the following as difficulties in cooperating with the U.S. There often seems to be an issue on release of technical information. They complain of being "ambushed by the many", a reference to the large number of players in the U.S. approval process. They acknowledge commitment at the working level, but lacking in the staff and financial community. The "NIS syndrome" was mentioned. This is an Australian perception that if the defense article is "not in service" in Australia, then the U.S. is not interested. Also mentioned as difficulties were the great distance between the two nations, the 12-hour time difference, differing national priorities and the size mismatch on production rates and quantities.

Due to our long history of military cooperation, lack of economic competition and common motivations for armaments cooperation, there exists few difficult cooperation issues from the U.S. perspective. Access to software source codes is an issue, but the U.S. historically does not release these to any nation. Australia seems like a natural candidate for expanded cooperation.

Japan

An understanding of the potential for cooperative acquisition projects with Japan must begin with a review and

understanding of Japanese policies regarding their defense relationship with the United States. These policies include the Japanese "No War" Constitution (post World War II), the Mutual Defense Assistance Agreement (1954), the Japan-U.S. Security Treaty (1960), the Three Principles on Arms Export (1967), Government Policy Guidelines on Arms Export (1976) and the Agreement on Technology Exchange (1983). Basically these policies preclude Japan from exporting armaments, and from sharing defense technology with any nation other than the U.S. There is an anti-military sentiment within Japan, and to further confound cooperation there is an anti-Japanese military sentiment in neighboring Far Eastern nations. There are deep cultural differences between us. The economic difficulties between the U.S. and Japan are reported almost daily in the American press. In summary, many external factors hinder the formation of cooperative acquisition projects with Japan.

The Japanese Defense Agency (JDA) conducts very little in-home research, but cooperation in research is the most feasible area. This is because the JDA does not purchase unlimited rights to intellectual property associated with defense articles, unlike the U.S. practice. The Japanese favor classified agreements which further complicates cooperation. The Japanese examine the possibility of cooperation based upon four "merits". These merits address the following areas:

- Appropriate for the Japanese environment.
- Improvements after procurement possible using Japanese technology.
- Long term logistics support available.
- Enhances the growth of the Japanese defense industrial base and technology.

While Japanese indigenous RDT&E is of paramount importance, the Japanese view some cooperation with the U.S. as "necessary." Japan responds to U.S. initiatives in cooperation, seldom if ever initiating cooperative acquisition projects.

Issues which may arise in cooperation with Japan include technology transfer and control (especially software), differing capability of two defense industrial bases, joint ownership of intellectual property rights, and technology flowback. The last issue has been persistent due to disagreement over the meaning of native Japanese technology and the requirements to provide this, or flow this back, to the U.S.

Real cooperation is only possible with the U.S. Japan favors the Data Exchange Agreements and the Systems & Technology Forum for identifying cooperative opportunities. The future of cooperative acquisition projects will be on a case-by-case basis, with clear and complementary motivations often lacking.

South Korea

Recent moves toward democracy in South Korea have reduced the influence of the military. However, defense industry still responds to government direction. High technology transfers to South Korea are considered in the context of potential conflict or reunification with North Korea. South Korea does little pure research, and therefore favors coproduction. All cooperative projects must have application.

As with Japan, there are deep cultural differences between the U.S. and Korea. To an American, Korean progress from point A to point B is never a straight line. Anticipate the Koreans to pay great

attention to detail, and to put almost everything in writing. Saving face and avoiding fault are vitally important to the South Koreans. Cooperation with the Koreans can be personality dependent. Anticipate changes to the project with changes in key personnel. South Koreans place emphasis on social activities, often at the expense of administrative support. Anticpate the need to provide administrative support, even in the translation of English to Korean. Also anticipate a strong empahasis on adhering to schedules.

South Koreans view cooperative projects with the U.S. as easy to start, but difficult to continue. They also view the U.S. as reluctant to make cooperative projects with South Korea work. Therefore, they speak of "turning our eyes," a euphemism for more government and industrial defense cooperation with other nations, primarily France and Germany. However they still claim to be actively seeking cooperation with the U.S.

The issues which typically arise in U.S.-South Korean cooperative projects include technology transfer and control, third party sales, intellectual property rights, total project cost and Korean cost share, and the transfer of research work to a defined project. The Koreans favor Data Exchange Agreements and the Engineer Scientist Exchange Program for identifying cooperative projects.

INTERNATIONAL ACQUISITION TOPICS

The study yielded information on the following list of acquisition related topics, each of which is explored in detail in this section.

* Project profiles
* Project office profiles
* Project initiation
* Program rationale
* Barriers to cooperation
* Potential partners
* Facilitators of cooperation
* International concerns
* Requirements/Goals
* Equitability
* Acquisition concerns
* International training

Project Profiles

All the projects in the PACRIM study were research and development projects, at least half of which also included some significant test and evaluation. These were relatively small R&D efforts of about $10-$15 million, only half of which had procurement potential. These were primarily technology demonstration/insertion projects, or technical data gathering projects. There were two exceptions. While the Japanese Next Generation Support Fighter (FX-X) Project is a major acquisition program for Japan, it is a very small effort in the U.S. consisting primarily of monitoring the technology flowback. The other exception is the U.S./Australian Nulka project or the MK-53 Off-Board Active Decoy as it is now called. The intent is for this project to go through development and into production. Almost all the projects are of moderate to high technical risk, as might be expected in early R&D. Commercial spin-off was viewed as a possibility in half the projects.

Project Office Profiles

While fully integrated international program offices with oversight and guidance provided by an international steering group is favored in NATO cooperative acquisition projects, this was not necessarily true of PACRIM projects. The favored approach in over half the projects was a dual project office structure, where funds and technical effort were managed in each nation, with a sharing of technology and results regularly during the conduct of the project. The lead nation

approach was the second most favored approached in almost a third of the projects. There were no integrated international project management offices in any of the PACRIM projects. This could be attributed to any or all of the following: lack of project maturity, bilateral nature, and the stipulation attached to Cooperative Research & Development funds (aka Nunn Amendment funds) that the U.S. portion be spent in the U.S. While there were no integrated international project offices, three approaches were employed to facilitate the international nature of the projects.

1. Liaison officer: This was used with the Japanese FS-X project and the Australian Nulka project, the latter having an Australian liaison officer in the U.S. project office, with no reciprocity.

2. In-Country support: This method was favored with the Korean projects, with the support provided by the Joint U.S. Military Advisory Group.

3. Embassy Contact: This was the approach clearly favored with the Australian projects, where their embassy in Washington, D.C. plays an active role.

The use of an international steering group, so highly favored in NATO projects, was used in only half the PACRIM projects. While those who utilized a steering group believed this structure beneficial, the other half believed that a steering group was not necessary.

Project Initiation

The study addressed the mechanism, rationale, barriers, and facilitator for program initiation, as well as an assessment of international partner potential. Regarding the mechanism for program initiation, the surprising finding was that there was no common approach or forum for this. As Table 4. illustrates, each project began differently. While only one project initiation was attributable to a data exchange agreement, half the project offices mentioned that an existing agreement greatly facilitated the project.

Program Initiation Mechanisms: All Are Different

* Defense Security Assistance Agency Initiative
* Bilateral Forum
* Office of Secretary of Defense Directed (To solve technical problem)
* Data Exchange Agreement
* Senior Level Bilateral Meeting
* Multilateral Forum
  - 5 Nations Meeting
  - ABCA Forum

Table 4.

Program Rationale

Examination of the motivation of U.S. project personnel to enter into international acquisition projects could help to identify future candidates for cooperation. Not surprisingly over half stated that a common threat or need was the motivation. While this is the expected answer, almost half had another motivation. A big reason was to access cooperative R&D funds. Other rationales were political motivation, technical benefit and standardization goals.

Barriers to Cooperation

The U.S. view on barriers was very clear. All the projects but one identified the cumbersome MOU/MOA process as a barrier to cooperation. The specific problem or complaint took many forms and involved such things as the difficulty of staffing the MOU/MOA, the length of time associated with the process (almost always significantly underestimated), and the difficulties associated with a change of legal advisor, reopening a MOU to negotiation, and the use of a programme MOU (for the

entire R&D and production cycle) vice an MOU for a single phase of acquisition. Only one other barrier surfaced. In half the projects, objections from other agencies or departments were identified as a problem. Mentioned in order of frequency were the Defense Technology Security Administration (DTSA), the Departments of Commerce and State, and finally other Military Departments.

The allied view identified cumbersome U.S. procedures as the major barrier to cooperation. While the MOU process was mentioned most frequently, the allies also mentioned encountering difficulties with our testing and technology release procedures. Surprisingly almost half the PACRIM allies' project offices cited national budget processes being out of phase as a barrier, while U.S. project offices never mentioned this as a barrier. U.S. project personnel need to be more sensitive to our allies' differing budget cycles.

Facilitators of Cooperation

Not surprisingly, over half of the U.S. project offices representatives focused on the project requirements. The term "requirements" could refer to a technical objective, operational requirement, specification or numbers of production units, and was not defined. Nevertheless, clarity, stability and mutual understanding of project requirements were considered to be of paramount importance. Also cited with nearly the same frequency was high level commitment and support to the cooperative project. Specific examples (ie. Ducted Rocket Engine) were mentioned that without OSD support the project would have never moved forward. Other facilitators cited were a perception of equitability of benefits, having an in-country liaison, and common program objectives. An interesting note was that only one U.S. project office stated that they had no significant problems during the MOU process. They gave the reason that they had engaged in two years of preplanning and technical discussion under an existing Data Exchange Annex (DEA) with their allied counterparts prior to entering the formal international negotiation process.

A comparison between U.S. and allied views on facilitator for cooperation was most revealing. One of the two most common responses from allied project offices was having a common goal. This was similar to the U.S. view but seemed oriented toward broader program goals, rather than the specifics of technical or operational requirements. The other most common response was "trust". This was a surprise in that it was the number one allied answer, but was never mentioned by U.S. project office representatives. This same phenomenon occurred during studies of European projects[5],[1] where the need for "commitment" was mentioned often, but exclusively by the Europeans. This suggests a profound cultural difference between the U.S. acquisition personnel and their allied counterparts regarding the value placed upon trust and commitment necessary in an international project. Two additional answers were mentioned: complementary skills/technology and prior meetings, neither of which appeared on the U.S. list. It is essential to understand the differences in motivation, and that all differing sets of motivations must be satisfied to attain success.

Potential Partners

Here again the differences between the U.S. and allied views are revealing. When asked about the desirable characteristics of a potential international partner, U.S. project office personnel found consensus on only one answer: mutual interest. No other answer appeared more than once, but the list included: available funds, win-win

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5 Farr, op.cit.

attitude, high level advocacy, technical capability, commitment, a signed royalty agreement, or a perception of urgency. One of the two most common allied responses was common goal/need, similar to the most prevalent U.S. response. However, it came from less than a third of the project offices, and was equal in frequency of mention to complementary skills/technology. The latter was never mentioned by U.S. representatives. Other responses referred to the existence of a political alliance, past experience, proven performance and reliability, interoperability of defense equipment, and equal partner mentality.

International Concerns

An assessment of five aspects of international projects as to their impact upon Pacific Rim projects was conducted. Both the U.S. and allied views were considered.

Geographic separation

The first international aspect examined was geographic separation. Not surprisingly the U.S. project offices viewed this as a problem with all three of the nations considered. What was unexpected was that our Australian, Japanese and South Korean counterparts minimized the importance of this aspect. They often cited modern technology easing this problem. First hand experience proves the necessity of a 24-hour fax machine for efficient communication.

Cultural Differences

The second international aspect examined was cultural differences. The U.S. project offices cited this as a significant problem when working with Japan and South Korea, but of minimal concern with Australia. Not surprisingly the Australians agreed with the U.S. view. The Japanese saw cultural differences as a problem, but not a significant one. The surprising response from the South Koreans was that cultural differences between the U.S. and South Korea were of minimal impact in international projects.

Language Differences

The third international aspect examined was language differences. Not at all surprising was the agreement between the U.S. and Australians that this was a minimal impact on an international project. However, a few Australians mentioned that subtle differences in meaning and pronunciation occasionally caused a problem. A personal experience at the Sydney airport illustrates this point. It took me three times to get a cup of coffee because the lady behind the counter kept asking me "what?" after each request. As it turns out she was really asking me whether I wanted my coffee with milk, or coffee "white" as it is commonly called in Australia. The U.S. project offices agreed with their Japanese counterparts that language was a problem, but not significant. It was stated that most of the Japanese we deal with in cooperative defense acquisition projects were educated in the U.S. and could read English very well. There was some difficulty cited in the spoken English. Regarding the South Koreans, the U.S. saw language as a significant barrier to cooperation, while the Koreans saw it as a lesser problem. This was expressed by one Korean project officer: "Language differences are not a great problem because we speak the common language of science." Like their Japanese counterparts, many South Korean scientists obtain some of their education in the U.S.

Technical Capability

The fourth international aspect examined was technical capability, especially whether differences in technical capability between the U.S. and partner nations caused

significant problems. There was consensus between the U.S. and allied project offices that this was a problem, but not a significant one. There were two exceptions. The South Koreans did not believe this to be a problem. The U.S. project offices believed that this was not a problem with Japan at the technology level, but that the integration of technologies, components and subsystems into a major defense system could be a concern.

Managerial Differences

The fifth and final international aspect examined was managerial differences. There was clear consensus between U.S. and allied project offices that this was a problem area. Not a single nation indicated that this was of minimal impact. There were varying degrees of concern by country. The U.S. and Japanese project offices agreed that this was a significant problem area. The U.S. project offices believed this also was a significant problem with the South Koreans. The South Koreans did not believe it to be as significant as the U.S. project offices. The U.S. and Australian project offices both believed this to be a problem area, but not as significant as with Japan. Unfortunately, the study did not get into the specifics of the managerial differences that caused problems, and is an area worthy of additional research. In summary, managerial differences appear to be the greatest international concern in intentional cooperative acquisition projects with PACRIM nations (especially with Japan), differing technical capability caused some concerns and the geographic separation, cultural differences, and language differences seem to be of lesser impact. However, in general the U.S. project personnel viewed the international concerns as more significant barriers than their allied counterparts. Most of our allies are used to obtaining defense equipment from outside their own country, while the U.S. is accustomed to purchasing domestically produced defense equipment.

Requirements/Goals

An assessment of the project requirements/goals process was conducted. This covered technical requirements, operational requirements, and/or general project goals agreed upon by the nations involved. This was found to be the most troublesome aspect of the NATO-Europe projects. However, with PACRIM projects, we either learned some lessons from the NATO-Europe projects, or it is just too early in the acquisition cycle to detect problems with the requirements/goals. The findings were that the requirements/goals were jointly developed, specified at the onset of the project, user needs were apparent, and there were no significant problems. There was one significant problem with the development of the requirements/goals. Political pressure altered the goals in half of the programs, but only before the MOU was signed. After the exposure to the formal MOU process, the requirements/goals stabilized. This points to a strong need for the acquisition manager to minimize the exposure time of the project to the formal MOU/MOA process.

Equitability

Since there is a statutory requirement that international cooperative programs be "equitable", U.S. project offices were surveyed as to their opinion on the benefits received by the U.S. and their perception of the benefits received by their partners in the project. As Figure 1. shows, the benefits were perceived to be moderate to significant. Clearly the U.S. project offices perceived equitable benefits from the cooperation. Partner exploitation did not appear to be a problem as about three quarters of U.S. project offices believed that neither partner was exploited and the remainder said it was too early to tell.

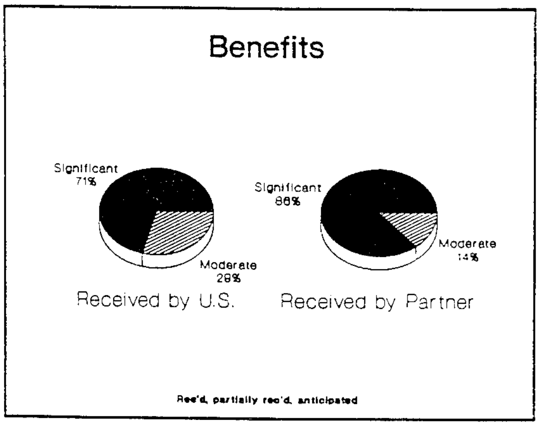

Figure 1. Equitability

Acquisition Concerns

A general assessment was conducted of the key areas of acquisition uncertainty associated with these international projects. This is shown in Figure 2. Especially pronounced were the high percentage of projects experiencing impacts on cost and schedule. The areas of uncertainty are clearly identifiable and appear significantly frequent. Regrettably, there is no comparable set of data for domestic acquisition projects, which might show similar problems.

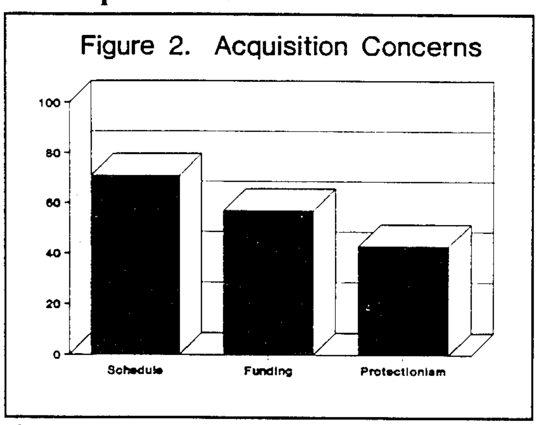

Figure 2. Acquisition Concerns

International Training

An assessment of the international training needs of the U.S. project offices was conducted. Fully two thirds said that it was needed, and would have helped the early stages of the project. The topics most frequently mentioned were international agreements and intellectual property rights. Also mentioned were third party transfers beyond the nation participating in the project, cultural aspects, foreign policy, and Foreign Military Sales (FMS).

General Comparisons Between NATO-Europe and Pacific Rim Projects

Table 5. lists some general comparisons between the NATO-Europe projects from previous studies and the Pacific Rim projects examined under this study. The key point is that the cooperative projects from the two regions are considerably different. I conclude that anyone well versed in cooperative projects with European nations may need to relearn the business when working with the Pacific Rim nations.

General Comparisons

NATO-EUROPE	PACIFIC RIM
Many Projects	Few Projects
Growth in 70's/80's; Recent Declines	Recently Emerging
Larger RDT&E $	Smaller RDT&E $
Cooperative Development and Production	Cooperative R&D
Expect & Desire Production	Production Intent Unknown or N/A
Many Multilateral	Almost Exclusively Bilateral
Intra-European Cooperation Common	No Intra-PACRIM Projects
Mixed Political Support	Less Political Support
Significant Cultural Differences	Enormous Cultural Differences
Complex Management Structures	Lean Management Structures
Traditional Program Manager	Technical Project Coordinator
International Program Management Offices	Key Individual In-Country or Coordination through Embassy
Collocation	No Collocation
More Use of Steering Committee	Less Use of Steering Committee
Commitment Important	Trust Important

Table 5.

FINAL THOUGHTS

PACRIM Cooperation Is Different True cooperation in acquisition projects is in its infancy in the Pacific Rim. It is twenty years behind our efforts with the NATO-Europe nations. Experience with NATO projects may be of little value in the Pacific Rim. Has the U.S. defense acquisition community learned the Rx for success? On the one hand we seem less prone to cancelling international projects; on the other hand, the projects have degraded to rather simple, early R&D efforts. Each nation merits a special remark. Japan is unique. Japan is most difficult to work with because of managerial differences and their pacifist policies. However, Japan is technologically mature, and therefore offers the potential for significant mutual benefit from cooperation. The conundrum with cooperation with Japan in acquisition is that it is simultaneously politically driven and politically opposed. Cooperation with South Korea will be clouded for the near future due to our difficulties with North Korea and the uncertainties associated with reunification. With respect to cooperation in acquisition with Australia, it is difficult to understand why there is not more. While some difficulties exist, I could find no clear reason for the minimal amount of cooperative projects.

Expectations for cooperative projects with PACRIM nations should be realistic. The key to future success will be to demonstrate commitment and build trust. As a final thought on the different nature of cooperation in the Pacific Rim, is that I believe that the multiple bilateral approach may not provide sufficient synergy for continued cooperation. Is there a forum in which all the nations could participate to increase cooperation?

Anticipate Problems

There are key problem areas that the acquisition manager should anticipate when entering into a cooperative project in the Pacific Rim. These are the known unknowns; there are no clear solutions, but certain strategies can mitigate the impacts. First and foremost, anticipate significant problems during the formal international agreement (MOU/MOA) process. Anticipate this to result in changes to project objectives, schedule delays and funding problems. These agreements normally are signed at very high levels, sometimes as high as the Secretary of Defense, and seldom lower than the Defense Under Secretary or Service Secretary level. This causes many organizations to participate in the process, many of which have conflicting agendas. The strategy is to minimize your exposure time to the political levels encountered during the MOU/MOA process. Some of these problems may be reduced with the recent streamlining policy promulgated by the Deputy Secretary of Defense.[6]

It is imperative to resolve as many issues as possible before starting to negotiate formally. Many technical points can be resolved under a DEA. The main restriction is that a draft MOU/MOA, or similar document cannot be tabled or even discussed.[7] I advise all acquisition managers even contemplating an international cooperative project to get a DEA in place as quickly as possible and use it as a vehicle to resolve as many issues as

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[6] Memorandum from the Deputy Secretary of Defense, dated 14 September 1994, Subject: Streamlining the Development of International Research and Development (R&D) Agreements.

[7] DoD 5530.3, International Agreements, June 11, 1987.

possible prior to formal negotiation. In other words, minimize your exposure time to the highly political MOU/MOA process.

Second and nearly as troublesome, anticipate objections to your international project. These objections can come from virtually anywhere to include other Military Departments, other DoD agencies, and other government agencies (including State, Commerce, and possibly Treasury), as well as the Congress.

The international acquisition manager is a consensus builder dealing with a plethora of nay sayers far exceeding that found in domestic program. Begin coordination early to build consensus. Advocacy for your international project within the OSD and services international programs staffs is essential. With this it will be difficult; without this impossible.

A List of Do's

While international cooperative acquisition projects are fraught with pitfalls, they can be successful. In fact all the projects studied were considered successful, and most or all will successfully meet their original goals. Based upon this study, and the years of research preceding it, I proffer the following "list of do's."

1. Concentrate on mutual benefits and needs.

Always try to assess your allies' needs, and arrange for equitable benefits. While the equitability of the project from a strictly U.S. view will be determined by many sources, no one in the U.S. is responsible for looking at our partner's needs. The acquisition manager is normally the one who must live with the agreement and execute the international project. He or she should strive for a win-win situation, if additional international activities are envisioned.

2. Take fresh, creative approaches.

International projects add a layer of complexity to an already difficult acquisition process that does not readily accommodate international projects. Recent initiatives and innovations may smooth out some of the difficulties. Some examples are the recent streamlining of the international agreements process, the use of special types of agreements (such as the umbrella and chapeau agreements) a computer program to assist agreements negotiators, and the use of DEAs to resolve early issues. Surely, more creativity will be needed during the project execution phases, beyond just the approval of the MOU/MOA.

3. Stabilize and clarify requirements.

While requirements did not appear as problematic as in the past studies of a NATO-European projects, it is too soon to tell whether this will become the show-stopper as some of the projects progress through the acquisition cycle. Nevertheless, even at these early stages, stable, clear requirements were well recognized as the primary facilitator of a cooperative project, especially by the U.S. project personnel.

4. Prepare and coordinate up front and early.

Consensus and advocacy are essential elements in all acquisition projects, but the level and span for international projects is much greater and extends beyond just the DoD.

5. Minimize exposure time to the MOU/MOA process.

Exposure to the political levels during the formal negotiation process is likely to result in changes to project goals, as well as significant impacts on schedules and funding. The acquisition manager must exert every effort to shorten exposure

time by building consensus and resolving issues before the process formally begins.

6. Learn to be trustworthy.

This was the greatest cultural divide between Americans and our allies. Trust is of great importance to our Pacific Rim allies, but never mentioned by Americans as essential elements of cooperative acquisition projects. This seems to be further exhibited in the U.S. approach of addressing every possible contingency in the extraordinarily lengthy, detailed project agreements, for which we have resorted to computer programs to develop.

7. Train and educate acquisition professionals before they start the international dialogue.

It was clear during the study that none of the U.S. project personnel had taken advantage of available international training. This deficiency has been noticed and documented before.[8] International projects require PET: preparation, experience and training. The reality is that U.S. personnel often pull the proverbial "PET" rabbit out of the hat when it comes to international projects. On October 1, 1994, all of DSMC's three international acquisition courses were officially identified as "assignment-specific Defense Acquisition University courses" by the Under Secretary of Defense for Acquisition and Technology. It remains to be seen how this will be implemented within the acquisition workforce. The services have already expressed a desire to send nearly 10,000 acquisition workforce personnel to our international courses. I believe this will bring about a grass roots revolution in our ability to engage in international projects. The ultimate solution will be to have certified international acquisition corps personnel managing all of DoD's international projects and related activities.

LIST OF ACRONYMS

ABCA - American-British-Canadian-Australia (Refers to the standardization agreement and organization comprised of these countries, with New Zealand as an observer.)

ADD -Agency for Defense Development (Refers to the South Korean Defense Agency responsible for development of defense equipment.)

AFB - Air Force Base

DAU - Defense Acquisition University

DEA -Data Exchange Annex (Refers to an annex on a particular technical area to a Master Data Exchange Agreement between the U.S. and another nation. Allows for the international exchange of scientific and technical information among scientists and engineers.)

DMA - Defense Mapping Agency

ESC - Electronic Systems Command, USAF, Hanscom Field, MA.

FS-X - Fighter Support-Experimental (Original designation of the next-generation Japanese tactical fighter. Now designated as the Next Generation Support Fighter.)

JDA - Japanese Defense Agency (Equivalent to the U.S. Department of Defense, but is not a cabinet level department.)

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[8] Richard Kwatnoski, "Negotiation of International Cooperative Defense Acquisition Agreements: A Case Study," Program Manager, September-October 1992.

JORN - Jindalee Operational Radar Network (Refers to a large Australian project which included the U.S.-Australian Radar Activities, or Over-the-Horizon Radar, Project.)

JUSMAG-K Joint U.S. Military Advisory Group - Korea (See also MDAO and ODC as similar organizations in Japan and Australia.)

MDAO - Mutual Defense Assistance Office (See also ODC and JUSMAG-K as similar organizations in Australia and South Korea.)

MICOM - Missile Command, U.S. Army, Huntsville, AL.

NRL - Naval Research Laboratory, Washington, D.C.

ODC - Office of Defense Cooperation (See also MDAO and JUSMAG-K as similar organization in Japan and South Korea.)

PEO - Program Executive Officer

PM - Project Manager

PMO - Project Management Office

PO - Project Office or Officer

SPO - Systems Project Office

S&TF - Systems and Technology Forum (A bilateral U.S.-Japan forum for exchanging technical information and identifying potential cooperative projects.)

TAD - Theater Air Defense

TCES - Technical Center for Explosive Safety, U.S. Army, Savanna, IL.

TRDI - Technical Research & Development Institute, Tokyo, Japan (The research and development part of the Japanese Defense Agency.)

TTCP - The Technical Cooperation Program (A program created to acquaint participating countries - see ABCA - with military R&D programs to promote international cooperation.)

LOGISTICS APPROACHES AND ISSUES

NEW METHODOLOGIES FOR INTEGRATING "STOVEPIPES" ... APPLYING INFORMATION TECHNOLOGY TO THE NAVY'S LOGISTICS SUPPORT CHALLENGE

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ABSTRACT

Today's Navy faces an environment that restricts personnel staffing, distributes responsibility for supporting logistics tasks and yet demands extremely rapid modifications to logistics support and operations support data. In the Navy's fiscally conservative environment, this can only that the Navy can expect in the future, this can only be achieved by applying new information systems methods and tools to access, update, and integrate the data stored in widely dispersed organizational information systems. This paper describes the design and implementation of an experimental database coordination and workflow management system for the logistics support processes to serve in this demanding environment for the Navy's *ARLEIGH BURKE* class guided missile destroyer.

Reducing the expensive shore-side infrastructure required to support the *BURKE* Class destroyer while not compromising warfighting readiness of the *ARLEIGH BURKE* class guided missile destroyers is the target for the AEGIS Program Manager's DDG 51 ILS Improvement Project. The first portion of this demonstration project has consisted of the automation of systems and coordination procedures to enhance the existing planned maintenance system for the ship's machinery control system.

The AEGIS Program Manager has focused the DDG 51 Logistics Support Improvement Project on interfacing six of the most important logistics support processes which promise to return the "most bang for the investment buck". Stand-alone hierarchical processes are commonly referred to as "stovepipes". These processes are: the Planned Maintenance System (PMS), the Engineering Change Proposal (ECP) Process, the Allowance Parts Lists (APL's), Ship's Manning Documents (SMD's), Training, and Technical Manuals. Each of these six organizational processes are executed by thousands of Navy civilian, uniformed and contractor support personnel widely dispersed across the country. In the past, these processes were accomplished primarily by FAX, paper based processes, "sneaker post" and the U.S. mail.

The new system's current major components are the product locator tool, a workflow management tool, and the six remotely distributed and independently maintained databases for the support process. The system utilized by the Navy requires a logical organizational data model and a relational database that allows for creative use of the relationships to identify and solve data associated logistics support problems. The goal was to utilize the model to eliminate unsynchronized entries into the database, and to avoiding building and storing complex rules that must be memorized and utilized by

sailors. The product locator contains a data model that integrates the data that are used in the stovepipe engineering and documentation system designs. In general, it appears that enormous productivity benefits may be derived from the application of integrationand icreased systems connectivity available with today's information system technologies. These benefits can begin to be tapped utilizing the workflow management and product locator capabilities.

INTRODUCTION

The United States Navy, like many other large public and private organizations, has attempted to implement large-scale organization changes. Among the changes attempted are significant efforts to maintain, synchronize and integrate access to logistics support databases that are geographically widely distributed and administered, and supported by separate functional command and decision making organizations.

BACKGROUND

At the climax of what was then called the "Revolution at Sea," Vice Admiral Joseph Metcalf, a former Deputy Chief of Naval Operations for Surface Warfare (OP-03), proclaimed this goal with dramatic overtones:

> 'Lead, follow, or get out of the way. This is not a job just for the Admirals. This revolution is an all-hands working party, committed for the long-pull."

His was a quest for improvement and change born of personal conviction and vision that only by radical and comprehensive reassessments of roles, missions, systems, technologies and operational practices, and addressing numerous organizational "religious issues" that worked to impede clarity of thought, purpose and action, could the Navy's surface combatants of the future place maximum ordnance on target. Since the publication of the Navy-Marine Corps white paper, From the Sea, in early fall 1992, the Navy has labored to make ready for the 21st Century. The Department of the Navy is addressing strategy, policy, doctrine, force structure, operations, tactics, shore-side infrastructure, and a myriad of other factors from the top-down and bottom-up in what some see as a "no-holds-barred, nothing-is-sacred" assessment. Their ultimate goal is to ensure that requirements and resources are better aligned, and that missions are fulfilled without a return to the "hollow Navy" of the 1970s.

INFORMATION SYSTEM CHALLENGES FACING THE EVOLVING NAVY

The system development requirements of the Navy have also changed dramatically, and methods and tools must now be selected to fit the Navy's business problems of downsizing and eliminating some tasks previously performed by reorganized programs and departments. The Navy now faces even more complex re-engineering and process innovation challenges. Information System (IS) requirements which must influence changing business operations represent a change from previous Navy information systems developers requirements to develop stand-alone functional systems with the support of specific units within the Navy.

Systems and projects to implement the Navy's current requirements must be composed of shared databases and many independent application systems. The role of Navy IS development is to now implement

strategic systems plans, and to collect, store, and provide access to the Navy's data when it is required.

This paper analyzes the growing requirement for new types of systems development methodologies that emphasize the use of new Commercial Off The Shelf (COTS) tools in combination with the integration of a number of other technologies that are applied to specific business and organizational management problems.

NEW DEVELOPMENT ENVIRONMENT

Assessments of the systems environment show that the Navy is now facing far different information systems development environments that include vendor supplied tools and software, with concurrent organization imperatives to modify the Navy's structure and operations to improve efficiency. New business and operational benefits can be realized by integrating today's COTS tools with the other organizational information systems. This is a never ending task with managers needing new and evolving developmental techniques. Navy managers concentrating on the acquisition, and integration of COTS tools with strong system integration and interfacing capabilities will find a substantial return on their investment.

In addition, Navy managers must provide software tools, control processes and communication methodologies for indexing, accessing, updating and sharing data across remotely distributed databases. Limitations in methodologies and tools have prevented the computer from becoming an important (if not critical) ingredient in this process in the past.

METHODOLOGIES

These new requirements have led the Navy to an understanding that a new set of environmental, technical and organizational methods and tools are needed for computer support and integration. New tools and methods are important for overall system success, and are far more possible and affordable than in the past.

It appears that the previous typical system development and life cycle methodologies contributed little to the diagnosis and solution of operational and integration problems of this new environment. The familiar software and system methodologies included the Classic Life Cycle otherwise called the "waterfall model" that describes a systematic, sequential development approach stretching throughout the analysis, design, coding, testing, and maintenance stages. The prototyping process involves building a model of the system, customer evaluation, refinement of the requirements, reworking the model, further refinement of the requirements, and eventually building the desired system using sometimes portions of the prototype (2). Neither approach addresses the complex integration and implementation issues found today. These problems require analysis, evaluation, decisions, and tools that address the individual and specific integration concerns that are not covered in the traditional methodologies.

A relatively new methodology, the Spiral model, seems to offers some promise for the implementation problems faced by administrative systems requiring significant conversion and data transfer. The spiral methodology encompasses features of both prototyping and the classic life cycle. It

includes four major activities: planning, risk analysis, engineering, and customer evaluation. Progressively more complete systems are built as developers move through the four stages in a spiral (2).

This new methodology is required because the system criteria for assessing whether or not logistics support requirements for ship systems and equipment are effectively met for the AEGIS cruisers and destroyers have now changed dramatically. But the computer support methodology and tools to support systems designed to integrate these requirements have not kept up with the requirements evolution. In addition, the criteria used to assess the effectiveness of meeting requirements shifted in their relative importance. The Navy is now using a new set of criteria that stress effective systems integration as the measure of success for information systems that attempt to address an organization's needs. This article identifies four new criteria: speed, change distribution, auditability and labor efficiency.

These new system criteria address several military business problems associated with the limitations of the current Navy stovepipe-like information systems architecture. First, the Navy must now update its separate logistics support databases in a very short period of time. Therefore, speed is a critical factor in assessing the overall success of a management information system support process. Second, the Navy must ensure that all changes made to the data are completely propagated to the other stovepipe systems (databases). Third, the Navy must audit the common and shared data among the stovepipe systems, and assure that all data are correctly entered, updated and fully synchronized. Finally, the Navy's logistics support methodology must now be executed in accordance with new staffing limitations imposed by Congressionally mandated downsizing.

The Spiral method appears to be relatively more successful because today's Navy systems environment is facing restrictions in personnel staffing and distributes tasks among disparate command and logisitics support organizations. Yet, the Navy must still be able to rapidly disseminate modifications and changes to logistics support and operations support data. Such modifications can only be realized by rapidly integrating new information systems tools with the mechanisms that access and update dispersed organizational information systems. This article describes the design and implementation of a prototype database coordination and integration system for several of the logistics support processes for the Navy's newest surface combatant – the *Arleigh Burke* class guided missile destroyer. This project is in keeping with the long-term goal of the Navy to do more with less, while not sacrificing the ability of the United States Navy to conduct prompt and sustained combat operations at sea anywhere in the world. Most importantly, the methodologies, technologies and capabilities emerging from the project have the potential to be directly transitioned to any business process (government or the private sector), thereby capturing the cost savings benefits of fundamental business process re-engineering.

AN INFORMATION ARCHITECTURE

The Navy is moving toward an organization-wide information architecture, identified with a set of systems and projects to implement mission requirements. This information architecture is composed of shared databases and application systems. Its role is to collect, store and provide access to the

Navy's logistics support, training, engineering data and other logistical support data, as required. Databases and shared applications must be designed with common business objectives, and development projects must be implemented using cross functional teams to design the new integrated systems.

One experimental project using this Spiral development methodology and linked to the Navy's and the Defense Department's Computer-aided Acquisition and Logistics Support (CALS) effort, is being undertaken by the Navy's AEGIS Program as a method to decrease weapon systems life-cycle costs of the Navy's *Arleigh Burke* (DDG 51) class guided missile destroyers. Embodying the philosophy of "build-a-little, test-a-little, learn-a-lot," the DDG 51 class Integrated Logistics Support (ILS) Improvement Project responded to VADM Metcalf's challenge. The Project is now in position, and the Navy expects it to–

- evoke re-engineering of fundamental logistics support business processes within the AEGIS Program; and
- be the catalyst for fundamental business process re-engineering for the way the Navy manages technical documentation, trains sailors and maintains complex weapons systems in the 21st Century.

The AEGIS Program's raison d'etre is the design, construction, outfitting and delivery of AEGIS warships to the fleet, and the planning and execution of modernization and lifetime support for those ships, i.e., "total support, from cradle to grave." Indeed, from its inception more than two decades ago, this Surface Navy program always embraced three key commitments:

- to deliver the most modern, affordable, capable and war-ready ships in the world;
- to provide the best and most affordably trained officers and sailors to man those ships; and
- to maintain the readiness and modernization of those ships at the highest affordable state possible throughout their service lives.

Today, 27 *Ticonderoga* class AEGIS guided missile cruisers are in commission. Seven *Arleigh Burke* class AEGIS guided missile destroyers have been delivered, with another 22 either under construction or under contract. A total of 58 destroyers are planned.

REDUCING COSTS BY RECAPITALIZING THE NAVY

A critical underlying factor associated with each criterion of the Navy's program to ready the Naval Service for the next millennium is the Navy's requirement to reduce shore-side and other support infrastructure costs. This will allow the Navy to "re-capitalize" itself and maintain a sufficient force structure of trained and motivated people to meet the needs of the future. Additionally, reducing support infrastructure costs will allow "right-sizing" the fleet for the Navy's continuing extensive political-military commitments within the very real and austere fiscal constraints of today.

Reducing the expensive shore-side infrastructure required to support the *Burke* class destroyer is one objective of the AEGIS Program Manager's DDG 51 ILS Improvement Project. The solution lies in the capability of today's Information Technology (IT) and IT's ability to rapidly

integrate information horizontally across an organization.

TOOL REQUIREMENTS FOR NAVY LOGISTICS SUPPORT IS GROWING

The Navy now faces complex re-engineering and process innovation challenges. To solve these challenges, the Navy expects its information systems to meet some or all of the different, and in many cases, heightened criteria previously identified. These new criteria (speed, change distribution, auditability, and labor efficiency) may appear to alter the original system requirements and assessment criteria, which previously emphasized data input, retrieval, processing or calculation, and production functionality for predefined reports as the critical measures of effectiveness.

This change was observed in other information systems environments. For example, Orlikowski (1) cites the rationale for the adoption and use of Computer-Aided Software Engineering (CASE) tools as being in part derived from information systems managers' desire to implement a new methodology and corporate architecture that would facilitate the redesign of business units.

This documented attempt to influence business operations represented a change from previous functions that the information systems group supported in the organization. It is an added requirement (or an additional criteria) that may be used to assess the effectiveness of the information system of the organization studied. To meet this criteria, the organization must no longer attempt to develop stand-alone functional information systems with the support of specific units within the organization.

Orlikowski cites specific examples where organizations now modify their information architecture and implement the organization's requirements and evaluation criteria with new systems and projects. The new information architectures are composed of shared databases and application systems. The role of information systems is to implement strategic systems plans, and to collect, store and provide access to all of the organization's data, as required. Databases and shared applications are funded through common mechanisms, and development projects depend on cross functional teams to implement new integrated systems (1).

Today's Navy appears to face a very similar challenge, with a similar solution. The Navy's logistics support environment must incorporate the support data associated with rapid changes in technologies and disparate equipment/systems configurations aboard ships and aircraft. Its support environment must also complete upgrades in support systems, logistics support data, training requirements and technical documentation. These rapid changes can only be realized by using systems tools that are integrated with other organizational support systems.

Navy managers must select a mix of tools and systems to support all of the organizational facets of integration and concentrate on using these tools to coordinate the Navy's diverse logistics tasks. This article describes how the Navy's AEGIS Program is defining new requirements for logistics support systems and reevaluating criteria. This redefinition of requirements and reevaluation of criteria is intended to emphasize the use of information systems as organizational change tools for executing business process re-engineering within the logistics support processes for the *Arleigh Burke* class destroyers.

DDG 51 LOGISTICS SUPPORT REQUIREMENTS AND EVALUATION CRITERIA

The Navy's logistics support information systems are similar to systems found in many of today's corporate organizations. The systems combine many different features such as a Graphic User Interface (GUI) for front-end capture of information with a relational database, mechanisms for file storage and retrieval, and systems management controls using a work flow system. This systems environment is typical of organizations that are experiencing ongoing evolution in their information systems.

In general, these systems must store logistics data and supporting information in an organization memory that can be used within the organization. The organization memory will serve as a design and development data dictionary to support the ability to use the data model as a tool that can be used to demonstrate the characteristics of the business relationships among the business units in the organization. The data model must be compatible with systems design and in implementation to show how departments and units are related to each other. The tools that support these systems must link to the front-end, PC-based development environment of the organization, prototype-evolving applications, and integrate the various databases of the organization.

The AEGIS Program Manager, in the life-cycle support role for AEGIS class ships, funds the AEGIS Program's share of the Navy's enormous "stovepipe" logistics support organization for logistics support of AEGIS ships. Today, the Navy's logistics support infrastructure consists of separate and distinct organizational processes. In only rare instances (usually a crisis or other emergent situation that forces manual integration) do these processes interact with one another.

The AEGIS Program Manager focused the DDG 51 Logistics Support Improvement Project on horizontally interfacing information across six of the most important logistics processes that promise to return the most for the investment dollar. These processes are–

(1) Planned Maintenance System (PMS). This system administers and accomplishes preventive maintenance afloat and ashore.

(2) Engineering Change Proposal (ECP) Process. This is the process that reviews, approves, sequences and schedules proposed engineering changes.

(3) Allowance Parts Lists (APLs). These are the parts lists every ship maintains, which specify the spare parts and quantities each ship shall carry.

(4) Ship's Manning Documents (SMD). These are the documents that describe how a ship shall be manned in terms of required numbers of crew and their skill levels.

(5) Training. This process provides for the correct training for ship's crews commensurate with the types of equipment and systems installed aboard the ship.

(6) Technical Manuals. This process provides for the production and life-cycle maintenance of the Navy's equipment and systems technical manuals/documentation.

Each of these six organizational processes are executed by thousands of Navy

uniformed, civilian and contractor support personnel who are widely dispersed geographically throughout the country. These processes are accomplished primarily in a paper environment, and employ FAX, "sneaker post" and the U.S. mail for connectivity. For example, it could be possible for a PMS feedback report originated from an Atlantic Fleet AEGIS ship, which recommended a change to an existing maintenance procedure, to pass through as many as three separate shore support organizations:
(1) COMNAVSURFLANT in Norfolk, VA;
(2) COMNAVSEALANT in Norfolk, VA;
and (3) the Philadelphia detachment of the Naval Surface Warfare Center – Carterock Division) before the change, if approved, is finally disseminated to all AEGIS ships.

Significant problems arise with this process if the new change in maintenance procedures recommended by that Atlantic Fleet ship drive other changes requiring–

(1) additional training for maintenance personnel;
(2) different spare parts;
(3) revisions to a technical manual/operators manual; or
(4) a reduction or increase in ship's manning requirements.

It may be many months before all of the changes are entered into "the system" correctly, and much longer before those changes ever reach the deckplates aboard an AEGIS destroyer.

MAJOR COMPONENTS OF THE SYSTEM

The basic objectives of the DDG 51 program are to use modeling and diagramming techniques to define the data, processing requirements, and workflows of the current logistics support process, i.e., the "as is" process, then, to employ Information Technology to replicate the process. Later, close examination of a model allows for calling into question each sub-process to determine its value in accomplishing the overall process. Process re-engineering can now begin using information technology to replicate the re-engineered workflow processes. If this sounds a lot like Total Quality Leadership/Total Quality Management, that's because that's exactly what is.

The system's current major components are the product locator tool, a workflow management tool, and the six remotely distributed and maintained databases. The system used by the Navy requires a logical organizational data model and a relational database that allow for creative use of the relationships to identify and solve data association logistics support problems. The goal was to use the model to eliminate unsynchronized entries into databases, and to avoid building and storing complex rules that must be memorized and used by employees.

The product locator is a crucial portion of the system that provides the logical data model. It serves as the essential database and driver for the coordination of all change drivers, and for locating logistics support equipment data. It contains a data model that stores the data that are used in the stovepipe engineering and documentation system designs, and may contain relationship data that indicate how various documentation and support databases are related to each other. The system is loaded with data that provide the information and guidance to make integrated and coordinated changes in the–

- Allowance Parts Lists;
- Technical Manuals; and
- Navy Training Plan and Manning Documents Planned Maintenance System Documentation.

ENGINEERING CHANGE PROPOSAL PROCESS

It is important to understand that the support processes being integrated using this approach are widely dispersed in geographic locations and are disparate in implementing technologies. As an example, the AEGIS Engineering Change Proposal (ECP) Process infrastructure for the Machinery Control System (MCS) aboard the *Burke* class destroyers is comprised of the prime contractor, Martin Marietta Corporation, Daytona, FL; the AEGIS Program's Change Control Board (CCB) in Washington, D.C.; the Naval Sea Systems Command also in Washington, D.C., which is the MCS life-cycle manager; the Philadelphia detachment of the Naval Surface Warfare Center - Carterock Division; the Supervisor of Shipbuilding, Bath, ME; and the lead shipbuilder of the *Burke* destroyer, Bath Iron Works in Bath, ME.

The development of the product locator by the Navy is a strategic step in the implementation of newer information system technologies to overcome the limitations of the organization's old and costly, manual, stovepipe-like environment. The new system is a conscious effort to modify the uncoordinated flow of information for logistics support functions that previously supported the independent processes and sub-processes.

Observations indicate that the stovepipes' support processes were primarily geared for production activities, and were not oriented toward answering management questions, supporting analysis of business information, or assuring that correct and complete changes had been made to all support documentation in all of the other stovepipe systems for logistics support. The benefits from the product locator are particularly important to the Navy in the multiple database access areas. The current stovepipe processes made it difficult to track multiple sources of logistics support data for one piece of equipment.

Logistics support changes made at different times or with slight variations in the name of the equipment or part modified are not always available for the sailor (and different organizations may have updated the data at different points in time). The impact of this problem is twofold. The sailor is confused, and the Navy must develop further complex training procedures to correctly use its rather unique and uncoordinated stovepipes (a direct cost to the organization).

A common product locator database under development by the AEGIS Program Manager for the logistics support of the *Arleigh Burke* DDG-51 class destroyer solves the problem because a single source can be examined to identify all of the ship's equipment and systems support data storage locations maintained by the Navy. Associations among the data can be reviewed. The overall result is better logistics support service, reduced training and decreased cost to the Navy.

WORK FLOW MANAGEMENT TOOL

Systems design and development literature emphasizes the enormous productivity and potential integration benefits from the increased systems connectivity available in today's information system technologies.

These benefits can begin to be tapped using the workflow management component of the DDG 51 ILS system when this system is combined with the product locator tool.

The work flow component has the capability of routing images and files throughout the logistics support organization network. It may contain embedded timers to check for the occurrence of an event or action. A file may be created in a special directory, and a process or transfer of data initiated to continue the logistics support processing. This enables the work to be monitored as it passes through the different functional areas. If the files or "folders" are backed up in one area for any reason, the work may be reassigned to another area for completion. The workload balancing enables all of the logistics support update tasks to be effectively sequenced and scheduled.

The work flow system may also be used to establish mailboxes, define processing routines, set timing and triggers for the execution of routines, establish processing diaries, maintain comments, and construct forms for use in systems processing. It has many multi-user capabilities that support the integration required across the different functions performed in the stovepipe systems. This helps to solve the enormous and expensive logistics support challenge that the Navy faces.

In perspective, the Navy is in a crisis as to how to manage all this information. Until now, the Navy was constrained to manage all this logistics support information using paper-oriented, page-based manual processes because the information technology required was either not available or not affordable.

The Chief of Naval Operations (Logistics), for example, estimates that the Navy produces 22.5 million page changes to technical manuals alone per year, using approximately 1,000 sailor man-years of effort per year, and costing the taxpayer approximately $400 million. For the AEGIS Program Manager, maintaining technical documentation for the sophisticated and highly complex AEGIS Weapon System (AWS) is proportionately just as expensive. The Navy has already begun transitioning AWS technical documentation from paper-based formats to highly interactive, digital format.

Similar problems exist in many other areas, such as the spare parts problem aboard an AEGIS destroyer. An AEGIS destroyer has approximately 23,000 spare part line items, with each item carrying its own distinctive part number. Each line item consists of at least one spare part, and most commonly there may be carried more than 1 unit of the same numbered stock item. In all, an AEGIS destroyer typically carries six times the number of spare part line items or approximately 138,000 spare parts.

To illustrate the enormity of the logistics crisis facing the Navy and all of the Uniformed Services, and to put this crisis in the perspective of simply being an information management problem, imagine a "worst-case" scenario where a sailor aboard an Atlantic fleet AEGIS ship identifies an electronic circuit card problem in the ship's Machinery Control System (MCS). The sailor immediately and correctly submits a feedback report on the problem, as required. For routine, non-safety related feedback reports, it takes a very long time (possibly months) to alert all other ships about the problem, its resolution, and the materials and instructions needed to fix the problem aboard other AEGIS ships.

In the interim, another sailor aboard an AEGIS ship in the Arabian Sea encounters the same problem. Not knowing his manuals and technical documentation are no longer correct, the sailor unwittingly attempts to fix the first problem. Incorrect tests are performed and ultimately, further damage occurs. The sailor attempts to obtain repair circuit cards from supply, but finds that they too are incorrect because the APL (allowance parts list) is outdated. New parts are requested. The correct parts arrive in 2-5 days, but problems still persist in the system, and the outdated technical manuals fail to cover these new problems.

Finally, the ship requests technical assistance. Support personnel (technical assistance team consisting of one or more technicians) are flown from the U.S. to Saudi Arabia and transferred to the ship. Armed with the correct technical information and skills, the technical assistance team quickly restores the MCS to full capability. Although this is a "worst-case" scenario, varying degrees of this scenario are all too common, tremendously expensive, and caused simply by inefficient information management.

APPLICATION OF THE SPIRAL METHODOLOGY

Systems integration efforts (using the Spiral development model) involves iterative development tasks. In the present development phase, electronically replicating the existing logistics support processes for the DDG 51 MCS is the objective. The benefits here are derived simply by efficiencies gained with eliminating paper roadblocks and queues, and moving information internally and externally electronically. In this phase, no attempt was made to re-engineer existing processes. The new system does not differ in data capture, front-end editing and task assignment/ oversight when compared to the old paper trail and manual processes.

The next phase of the project spiral had many options for demonstrating how artificial intelligence (AI) and decision support system (DSS) capabilities can be substituted for some sub-processes now done by people, thereby enabling reductions in support infrastructure and improving overall logistics support. For example, one option was to demonstrate how AI and DSS could improve processing by using a front-end data editing capability. Front loading with an expert system or decision support system to minimize errors in data entered into the system, assign the careful distribution of data among the systems, and to monitor updates to the databases might achieve significant reductions in existing support infrastructure.

Another option considered was to show how a decision support or expert system capability might enable the system to intelligently deal with any future changes that may occur in workflows of the major support processes, i.e., (PMS, ECPs, APLs, SMDs, TMs and training). If users modify their tasks, changes could potentially be propagated to the database or the business rules of the organization and eventually support AEGIS re-engineering efforts.

The third option (selected for demonstration) was to use an expert system to meet requirements for the storage and implementation of the customized logistics information processing rules of the Navy. These are the rules that select work processing sequences and determine how changes to logistics documentation are maintained. A complete expert system might eventually contain hundreds of business rules

for updating and handling the enormous amount of logistics documentation, engineering drawings, instructions, and technical materials that are currently maintained only in written procedures or in the corporate knowledge of sailors, Navy civilian employees or contractor support personnel. Sometimes, even the rules themselves may be unwritten. It may take months or years to train a sailor, civilian government employee or support contractor to become completely proficient at managing a logistics support task and understanding the rules. Over time, the system could be used as a primary logic editor for the application and will probably increase in size as the ILS systems mature. Data to be included in the system could encompass training information and related data that are stored in job descriptions of the In-Service Engineering Agent (ISEA). These documents could include training manuals, business rules for each system, written guidelines and procedural manuals.

As an example, the system will seek to demonstrate how it can be used as the business source of the rules that define what the MCS ISEA does to sort and sequence maintenance requests for system technical documentation and manuals when ECP-driven changes are processed. The expert system will demonstrate how it can provide data to the workflow management system, which checks tables to determine which tasks are to be performed next. If a status flag shows that a next task exists, the system will place the logistics support data, images, reports and associated documents in the electronic mailbox of the cognizant individual for further action.

Using this capability, the Navy could significantly increase managerial 'what if' capabilities that can be derived from the databases and environmental information available to the maintenance personnel.

FUTURE METHODOLGY: TAILORED TOOLS AND PROCEDURES FOR INTEROPERABILITY

Future systems development methodologies must utilize tools which match the step-by-step methodologies to the needs for software and systems that require extensive integration and development support. The broad functions performed by the tools must cover input to the design of systems, diagramming techniques, design specification which can produce code when fed into code generators, and testing and debugging tools to speed the acceptance and testing of software.

Specialized methods will be required to support:

- analysis and design for development and integration
- database and file design for integration data modeling
- data modeling to aid the maintenance of integrated systems
- programming tools for code generation and testing
- project management for planning and controlling complex tasks

The goal of the future "detailed" development methodologies will be to provide straightforward and easy-to-use instructions and technical guidance for the implementation of systems with multiple components. The methodologies will help to accomplish this goal by providing clear developer procedures for preparing the tools, detailing step by step instructions indicating how systems can be integrated, and guidance for the integration steps necessary to link

diverse systems after the actual development has been completed.

SUMMARY

The evolving DDG-51 information systems environment is typical of organizations that are experiencing an ongoing evolution in their information systems, concurrent with changes in the organization. These information systems must now store information in an organization memory that is accessible to all users of the information to serve as a design and development data dictionary; and to support the ability of organization members to utilize the data model as a tool that can be used to characterize the business relationships among the sub-systems in the organization.

This means that the system must be capable of identifying the impact of organizational changes, identifying overlaps and duplication in data, and noting where and how task re-engineering might impact operations by examining the business relationships identified through the data stored in the systems of the organization.

The question of "how" to accomplish this is a primary concern for managers who face unintegrated systems such as many of those in today's government and business environments. Far easier is to describe what has happened in this Navy program and why the change appears to be occurring here, rather than to proactively state how new information systems can be developed and effectively implemented for similar complex environments. For the Navy, the change appears to have been both strategic, incremental and evolutionary.

The implementation of the product locator and its workflow components is being carefully assessed to minimize any negative impact on the DDG-51 project, and to implement a systems strategy to transfer this new technology throughout the AEGIS program. Many factors seem to play a part in making the success occur. The timing of the change was a clear issue. This may include the business and technical motivation of managers in both the Information Resource Management (IRM) organization and in the AEGIS Program's functional areas. In addition, the evolution and availability of affordable computer programming tools, including the support tools, GUI front end, database, expert system, business rules, optical scanning and storage capability all appear critically important. For the AEGIS Program, price was also a critical issue. The high cost of mainframe tools would have made the adoption of a mainframe-based CASE system far less advantageous. Managers should continually evaluate the relationships between their Information Systems (IS) and business environment, and develop an ongoing approach to strategic planning that involves comprehensive strategies for adopting CASE and other tools that upgrade IS business and organizational support capabilities.

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REFOCUSING FOR THE 21ST CENTURY

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Defense Personnel Support Center

MISSION

The primary mission of the Defense Personnel Support Center (DPSC) is to support the war fighter in both war and peacetime by providing quality goods at fair and reasonable prices in the most timely fashion available. Everything we do, from small purchases to the institution of Electronic Commerce business systems, is done to support this critical and overarching responsibility. Systems and communications are simply enablers which allow us to support our mission.

VISION

The DPSC vision is to be the champion of military readiness, worldwide provider of federal logistical services and a leader in business innovation. We have combined the essential objectives of our mission - combat readiness and customer response - and placed the highest priority on their attainment, which encompasses having the right items, at the right time, place and cost. To attain these objectives, our quantum leap strategy is the DPSC Logistics R&D Program called $(CR)^2$; it is our blueprint for the future.

INTRODUCTION

For many years, the national defense logistics system depended on massive inventories of unique items produced to stringent military specifications. We supported our customers' readiness and peacetime requirements by using DoD's leveraged buying power to receive substantial discounts on stock that we then held in government warehouses until customers requisitioned it. By taking advantage of economies of scale, we were able to provide our customers with product at prices substantially below those they could acquire for themselves. In fiscal year 1994, our total sales were over $3.4 billion, an amount that placed us well ahead of many of the Fortune 500 companies.

Historically, we conducted much of our business on paper. Our business strategy was based on the assumption that holding inventory in our warehouses provided our customers with acceptable service and the lowest delivered product/service costs. We also assumed that awarding relatively short-term contracts to vendors on the basis of lowest price would achieve the lowest delivered cost. In reality, that process was slow, prone to error, and expensive. Customers routinely received product 60 days after ordering with a considerable surcharge (up to 28%) added to the price of the item.

READINESS IN THE NEW WORLD ORDER

The greatest challenge facing the DPSC and in fact, the entire DoD, is how to maintain a readiness posture in an era of reduced budgets, reduced peacetime needs and increased competition. In order to support wartime requirements, the DPSC must sustain, through contracts for

peacetime requirements, a robust logistics support system to include raw material suppliers, manufacturers and distributors capable of responding to rapid changes in demand. The DPSC is facing an increasing threat to its reduced peacetime sales base due to increased competition from other Federal agencies and the private sector. The erosion of our sales base results in the erosion of our ability to support an industrial base sufficient to meet our national defense and emergency readiness requirements.

The current business environment demands quicker response to marketplace changes, greater efficiencies and lower costs of doing business. Adjusting to that reality led us to fundamentally change the way we conduct our business. We realized that our processes and the assumptions on which we operated were not always valid. Like industry, we now focus on long-term relationships with our business partners to give customers what they want, when they want it, and at a price they are willing to pay.

The DPSC achieved a higher level of customer service through the use of Electronic Commerce (EC) initiatives coupled with reengineered business and logistics practices. These strategies offer an opportunity for the DPSC to not only become the supplier of choice to the military, but to also expand our sales base to include other non-traditional customers, thus enabling us to sustain ourselves during peacetime to be ready for our national defense and emergency responsibility.

BUSINESS ENVIRONMENT

REENGINEERING

We define reengineering as a fundamental rethinking and radical redesign of business practices resulting in dramatic improvements in customer satisfaction. In our reengineering efforts, we attempt to link all re-design efforts to corporate objectives, take a win-win approach with all our trading partners, reengineer processes before systems, and always remain customer driven. The ultimate goal is to do business in our industries in the way they do business. To achieve this goal, we emulate the best commercial practices without imposing government unique requirements.

ELECTRONIC COMMERCE

Of all the changes we are making to attain excellence in logistics support, integrating the use of Electronic Data Interchange (EDI) and other enabling technologies into our business systems to achieve total electronic end-to-end business transactions or Electronic Commerce, is the most significant. It has allowed us to fundamentally change our business and logistics processes and approaches in all of our functional areas.

Electronic Commerce is an advanced total business system that provides a solution to implementing our corporate business strategies. These strategies move beyond conventional practice and experience. The system takes full advantage of the opportunities available through commercial acquisition methods utilizing EDI technologies. We have taken and tailored the best ideas from several industries to develop our strategy.

The DPSC Electronic Commerce Program was designed to emulate successful commercial industry electronic commerce models. Electronic Commerce, sometimes

referred to as electronic trading, is a total business system which maximizes the use of information to hasten the movement of money and merchandise among long-term trading partners. One of the tenets of EC is the use of EDI, which is an enabling technology that permits the flow of information in a paperless environment through the use of standard formats evolved through industry consensus. These model systems use long-term trading partnerships integrating suppliers, vendors, manufacturers, distributors and end use customers in an EDI network.

Electronic trading requires a business system that permits the public sector to do business in the way each of its industries does business, i.e., using standard industry practices and EDI formats and deemphazing the uniqueness of government requirements and specifications. It is for this reason that we utilize the *industry* convention rather than a special government convention. At DPSC, we have the capability to communicate with trading partners in a variety of ways, e.g., using Value Added Networks (VANs), direct connections and government hubs. Our success is based in flexibility and adopting commercial, industry developed systems and standards.

DPSC is at the forefront in the development and demonstration of Electronic Commerce business applications. Our pioneering efforts in the public sector application of EDI are recognized by the Price Waterhouse Corporation. In its landmark benchmarking study of EDI business systems applications, DPSC is the only government invitee in a select group of 24 nationally recognized leaders in EDI such as JC Penney, IBM, Motorola and Texaco. Now in its second year of benchmarking, DPSC continues to place about in the middle of this prestigious group.

The application of EDI technologies to the large purchase arena (over $25,000), which constitute the bulk of DPSC purchases, is where true EC operates. The concept of electronic trading moves beyond the simple movement of information to include merchandise and money and deals with a variety of business concepts that affect a number of business functions including transportation, inventory management, finance, and purchasing. These relationships are complex in nature requiring suppliers to not only possess the capability to conduct EDI, but to also establish innovative, robust business systems that use EDI as a tool. Examples are our Prime Vendor and Quick Response Programs, where due to the rapid flow of information, suppliers can guarantee specific delivery requirements (some routinely in less than 24 hours) and adjust production based on actual usage. Here EDI, the tool, has permitted changes in inventory management, distribution and financial processes to move merchandise and money as well as data.

BUSINESS PRACTICES

Gone are the days of 700 page specifications for chocolate chip cookies and overloaded warehouses of 1950's vintage hospital gowns purchased based on erroneous forecasts. Today the DPSC buys commercial products manufactured in response to actual demand, delivered direct to the customer's door in a matter of days instead of the months previously required for delivery alone. Our objective is to either buy commercially available items or manufacture to actual demand as it is recorded at the point of sale or issue.

Three specific examples of reengineered logistics processes are "Quick Response", "Shared Production" and "Prime Vendor".

QUICK RESPONSE

Quick Response is the effective use of Electronic Data Interchange (EDI) coupled with modern inventory management and manufacturing techniques to speed the flow of information and supplies among the business partners. Point of sale data is collected from our customer and sent via EDI to the manufacturer's integrated automated information system. The data is used for production planning. Computer aided design and manufacturing technology is used to transmit technical documents and patterns. Flexible or modular manufacturing systems are employed to permit manufacturers to adjust production schedules as needed to ensure adequate stock replenishment. Delivery takes place within 72 hours after order. Supplies are shipped directly to the customer instead of to a government warehouse. Since implementing Quick Response customers have saved over $1 million in reduced government inventory and handling costs.

The flexibility provided by the Quick Response system permit manufacturers to quickly surge production in response to emergencies. The system was tested in October 1994 when Iraq once again posed a threat to Kuwait. Three Quick Response vendors began manufacturing and shipping tens of thousands of fatigue uniforms within ten days after order. Within four weeks, 100,000 sets of fatigues were prepared and ready for any troops that might be deployed. The greatest endorsement of the Quick Response system came from a satisfied customer who, after receiving a desperately needed item in five hours after order, exclaimed that it was a feat "nothing short of a miracle".

SHARED PRODUCTION

What do the McDonald's Corporation, NIKE, Nestlé, Hard Rock Cafe and the Department of Defense have in common? Long-term partnerships to ensure defense readiness in a changing world order. Lauded by Connie Chung of CBS News as "an example of defense conversion at its best", the Shared Production Agreement concept represents a major conceptual change in the defense planning process. The Shared Production Agreement concept, pioneered by the DPSC, partners manufacturers with the DoD and other customers to ensure production capacity for military requirements during national emergencies.

Under the Shared Production Agreement concept, commercial capacity and inventories are shared by the DoD and major non-defense customers such as McDonald's and NIKE, etc., who agree to share the production facility during peacetime or times of normalized requirements and facilitate dedicated production during surges in demand by either sharing partner. In the event of a national emergency, the commercial customer agrees to relinquish production lines and capability, as necessary, and return to its normal business relationship with the vendor as military requirements decrease. By sharing the production facility, the manufacturer's dependence on government contracts is reduced and defense surge capability is maintained and/or expanded at a reduced cost. This approach also ensures that contracts/orders in support of the national defense will be accepted and given priority, and makes industrial base planning with the DoD more attractive to commercial companies.

Rapid conversion requires the items produced for both the military and commercial customer be produced using similar, generally accepted commercial

manufacturing practices, by a workforce cross-trained and tested in both military as well as other customer production. Agile or modular manufacturing and EDI are the enabling technologies. These methodologies allow manufacturers to produce both large and small production runs of complex and critically needed items and deliver them directly to designated customers in an Electronic Commerce system.

The Shared Production program is supported by seven agreements to date and is growing. Replication of the Shared Production concept is being encouraged throughout DoD.

PRIME VENDOR

The Prime Vendor Program is a commercial distribution system that allows our customers to exercise their discretionary buying power to order only what they need, when they need it. Customers choose the medical or food item of their choice from an electronic catalog, and transmit the order electronically direct to the "Prime Vendor". Confirmation of the order is received in minutes and delivery occurs within 24 hours. Payment is accomplished through electronic invoicing and Electronic Funds Transfer (EFT) making Prime Vendor a total end-to-end Electronic Commerce business system.

The DPSC negotiates the contracts that underpin the program, performs contract administration and pays the bill for the customer all for a minimal 1% service fee. Leveraged buying allows the customer to take advantage of lower prices without investing capital in massive inventories. The program shifts the onus for holding and managing inventory to the manufacturer/distributor. The only inventory that will be held in government warehouses are those quantities necessary to support emergencies until surge agreements/options are activated.

The use of commercial items and distribution/inventory systems provides a higher level of flexibility and customer response. A medical Prime Vendor delivered critical medical supplies to the scene of a tragic airplane crash at Pope Air Force Base in North Carolina within 30 minutes of the incident; an impossible feat under previous distribution methods.

The Prime Vendor concept was initially piloted in the medical pharmaceutical arena. The program has since been rolled out to include medical surgical, food service and clothing items. Within DPSC, Prime Vendor currently accounts for 60% of medical and 20% of its food service sales and is growing. The high level of customer choice and service provided by the Prime Vendor Program has enabled the DPSC to retain sales threatened by the highly competitive environment in addition to capturing new sales.

CHALLENGE

Our national defense readiness strategies now heavily rely on immediate industry surge response and shared production agreements made possible through our electronic commerce business systems. It is crucial to our readiness posture that we partner with suppliers who will enter into long-term trading partner relationships with us to ensure product availability during national emergencies. The loss of even one critical supplier may have serious national defense readiness implications. The remaining challenge is to fully integrate these successfully demonstrated new logistics approaches into our readiness planning models and total business system.

FUTURE

ACHIEVING READINESS UTILIZING COMMERCIAL LOGISTICS SYSTEMS $(CR)^2$

The Defense Personnel Support Center is a leader in both Government and the private sector in the use and development of Electronic Commerce. The management at DPSC has successfully re-engineered business practices and processes in all commodity business units. Enabling technologies such as EDI have been implemented, paving the way for a totally electronic commerce environment in the future. The enhancements we have instituted through "Buy Response Vice Inventory" and other incremental process improvements have refined the way we do business today. However, like all successful businesses, we are planning today for the long range strategy that will carry us through the 21st Century and allow us to surpass the competition.

We have embarked on aggressive, bold new business practices which when totally deployed will change our business processes. Previous processes which segregated functions such as requisition processing, cataloging, contracting, distribution and customer service will be performed interactively and information related to these processes will be stored and available in an interactive mode. Therefore, it is necessary to develop a repository for all cataloging, technical, quality and contracting information which can be viewed and utilized for a variety of purposes. Rather than partition data into functional units, an on-line real time interactive database must be developed which not only services the purposes of DPSC for management of data, but also serves as a contracting tool for customers and a repository of public information for industry. An interface with an automated ordering system will be the path to the contracting tool. The system would act as a logistics manager, allowing DPSC to manage items and distribution methods while customers would actually be able to place orders using the system. Systems integration and enhancement is required to allow DPSC to maintain its position as a leader in customer support and combat readiness.

GOALS

The $(CR)^2$ initiative seeks to accomplish three goals:

- posture DPSC for a higher level of combat readiness in the new business environment;

- make DPSC an artery for customer and supplier entry/exit on the information superhighway;

- explore state of the art and leading edge advanced information technology for potential application and benefit throughout DoD and the Defense Logistics Agency.

COMBAT READINESS

The combat readiness portion of $(CR)^2$ will empower logistics planners to forecast a sustainment scenario in accordance with a specific force package. Modeling and hypothetical situation analysis will be used extensively to determine optimum solutions to current and future readiness dilemmas.

The plans to support two nearly simultaneous Major Regional Conflicts (MRC) specified by the current National Military Strategy will be addressed in $(CR)^2$. We will make assumptions about wartime requirements consistent with past experience and current projections. Additionally, we will use actual demand history from the most recent conflicts, humanitarian relief efforts,

and the two-MRC scenario to identify a second echelon of potential warstopper items. The $(CR)^2$ algorithm will offset these requirements with projected assets (on hand and due in) from depots and the Services. The algorithm will further reduce the requirement by the amount that the industrial base is capable of providing. The residual requirements represent the inventory investment or business arrangements that must be supported to bridge the gap between D-Day and the day that production can meet consumption.

$(CR)^2$ will be developed and tested in labs which will enable DPSC to share information and partner with other agencies. For example, we will partner with Advanced Research Projects Agency (ARPA) to incorporate specific technologies that enhance and empower our processes.

CUSTOMER RESPONSE

The DPSC Customer Response - Combat Readiness $(CR)^2$ System will reside at an exit on the Information Superhighway and will be accessible to any and all interested parties, to include military customer, manufacturers, dealers, industry associations, as well as public and private institutions. Access to the system would be the same as entry onto the Information Superhighway; through state of the art digital technology whether that be telephone modem or electronic network communications. Information will be partitioned into views to enable preferred customers unlimited access to data. Casual shoppers and competitors will also be afforded a view, but the scope and breadth of data will be a mere glimpse of what actually resides at that exit.

Preferred customers will be able to browse or purchase, gathering information at various levels of desired detail. Immediately upon access to our system, shoppers will be identified by their customer number. Items will be easily called up by a variety of lexicons, and searches will be tailored to the level of detail desired. Customers will see similar and identical products offered via differing methods of distribution, and will be able to make best value source selection decisions based on their individual needs. Prices will be displayed for various distribution methods and delivery times, enabling the customer to decide on the best selection. If desired, the shopper will be able to actually "see" the product in three dimensional presentations. The system will incorporate Computer Aided Design software to enable users to draw and display products.

Additionally, technical information concerning standards utilized in product manufacturing processes, dimensions, and other product information will be displayed. Information on quality history will also be available as well as recall and regulatory agency updates.

Customers and logisticians will have access to virtual inventories by viewing on hand stock levels at government and commercial locations, i.e., storage locations and distribution sites. This visibility will enable customers to make decisions on when to buy and how much to buy. Also, $(CR)^2$ removes the variance from the business environment. Buyers of goods will know specifically when product will be delivered to them; they will have a choice of delivery modes and related costs, however, there will be certainty associated with the choice. To explain, if the buyer chooses to wait three weeks to receive goods from a low cost supplier, that is the buyer's prerogative. However, he will know WITH CERTAINTY that the product will be delivered on a specific day. That certainty does not exist in today's environment.

Data entrance and exit to the system will

only be possible through the exclusive use of EDI standard transaction data sets. Owners of data will be responsible for ensuring accuracy while systems edits will protect the database from incomplete data sets entering the highway. Data calls will enable regulatory agencies to update new item entries with quality history prior to the item being available for wholesale viewing.

The system will run in a real time on-line environment. Commercial product classification software will be utilized to group like items to help customers shop in an orderly fashion without having to know the item number or stock number. When customers place an order, demand data will update the Customer Demand Management Information system. Also, depending on the distribution method selected, inventory adjustments will be made and orders for replenishment will be triggered either to DPSC, Central Distribution Centers (CDCs) or even Prime Vendors, to name a few of the choices.

Customers will enter the highway, exit at our database, browse and shop, select an item and method of delivery, enter a quantity and hit the order key. Immediate confirmation of the order with a delivery date and an order number will occur. The customer will be asked if the shipping address on file is the address desired. If it is not, an order specific address can be entered. He then drives off.

$(CR)^2$ - THE SYSTEM

$(CR)^2$ will result in quantum improvements in combat readiness and customer response by integrating operations across present commodity boundaries. The program will encompass all existing systems and processes, resulting in a seamless entry/exit into DPSC information and technology. The primary focus of $(CR)^2$ is to streamline and automate the interface between the private sector and the item's end user, the war fighter.

$(CR)^2$ will integrate emerging R&D concepts into an overall revolutionary logistics system. One of the primary issues is one of scope. Many emerging technologies that work well on a small scale and limited scope break down when the scale and scope are significantly expanded. The $(CR)^2$ initiative expands the use of emerging research to a larger scale and scope and tests them in a scaleable operational environment.

$(CR)^2$ will integrate our processes and systems by exploiting the natural synergism among our Commodity Business Units. This will be accomplished through cross pollination of proven technologies that have reached various stages of maturity within narrow operational areas. These technologies will be expanded, modified and enhanced to embrace a larger group of users.

PARTNERSHIPS

$(CR)^2$ will be developed and tested in labs which will enable DPSC to share information and partner with other agencies to incorporate specific technologies that enhance and empower our processes.

DPSC will invite the Services, DLA, our trading partners, and the information technology industry to participate in $(CR)^2$. Consistent with DPSC's current status as a DoD Demonstration Center for acquisition reform, best commercial practices, and electronic commerce, DPSC welcomes the participation of other DoD components as well as other Federal agencies.

SAVINGS

The Defense Personnel Support Center is part of Defense Logistics Agency, which is a combat support agency for consumable items. Each Military Service will benefit directly from improvement in DLA's ability

to support the war fighter with shorter lead-times and reduced cost. $(CR)^2$ allows DPSC to develop and test large scale projects related to the logistics mission. Based on the results of these tests, gaps in current research and advanced technologies that are mature enough for operational implementation are identified. The proposed development is a high risk, high payoff alternative to the logistics systems being developed and implemented through Corporate Information Management and DBOF funding. The program takes a holistic approach to the logistics system including the heavy reliance that will be placed on the private sector for privately held inventory. The most significant outcomes include improved combat readiness and customer choice in terms of items, source, cost/schedule tradeoff, and reduced transaction costs, as well as quantrum improvements in Logistics Response Time (LRT).

Improved Response: This will be accomplished through the synergy of the electronic catalog and Electronic Data Interchange technology. Customers will access the electronic catalog directly, avoiding the delays associated with requisition processing, and then experience instantaneous order entry through the technology of EDI. As soon as an order is placed by a customer, an 850 transaction is sent to the manufacturer/distributor. Customers receive immediate status regarding delivery date and mode of transportation.

Improved Customer Support: Improved distribution methods such as Prime Vendor, Dedicated Truck, Cross Docking and FEDEX Air will be employed as part of the business arrangements supporting the various price/quality choices. This will result in improved delivery time to customers.

Lower Prices: Negotiation of long term contracts, standing offers, distribution and pricing agreements, supply bulletins and other innovative acquisition instruments result in better deals for our customers. Industry is receptive to new approaches to contracting and has committed to offering best customer prices. DPSC, acting as the group purchaser for its customers, receives deep discounts due to volume, use of electronic order entry systems, and use of electronic funds transfer.

Reduced Inventories (at both retail and wholesale levels): As DPSC moves to a direct vendor delivery environment, drastic inventory reductions will occur at both the retail and wholesale levels.

Reduced Warehouse Space: As DPSC embraces direct vendor delivery methodologies and just in time inventory management techniques, there will be little need for traditional warehousing of government owned inventory. This results in decreased overhead expenses, allowing us to lower the surcharge to our customers while improving support in terms of faster delivery.

Less Infrastructure: As DPSC adopts commercial buying practices, the need for catalogers, technical writers, engineers, item manager, quality assurance specialists, and other functional specialists decreases while the Center becomes a contracting activity. Generalists will be employed to manage a multitude of functions associated with the logistical support of customers rather than diverse groups of functional specialists micro-managing parts of the process. Responsibility and authority will rest in the multi-functional team rather than in separate

parts of the organization.

MIS System: Development of an integrated system will allow DPSC to develop a Management Information System for all CBUs; this does not exist in today's fragmented environment.

Recovery: Use of a single system to enter and view data will mean that significantly fewer people are required for recovery if the physical data processing platform were to be destroyed. In today's environment, individuals who know existing legacy systems are needed for recovery. With $(CR)^2$, systems are integrated and entry and exit is uniform for all.

METRICS

In order to measure success, metrics are identified at the outset and can be tracked during the evolution of the program. For $(CR)^2$, the metrics we will track are:

Combat Readiness - we will track improvements in our readiness posture in terms of "percent ready". This metric will look to the establishment of business arrangements required to support two MRCs. The critical items will be established, quantities required will be calculated and then virtual inventories will be measured. The delta between existing private stocks and the value required to support two MRCs is the critical value to be measured. This must be covered through inventories (Gov't, virtual), shared production arrangements, stock rotation contracts, surge clauses and other business arrangements which when invoked, will support readiness at 100%.

Customer Response - we will track improvements in the consistency of support by measuring the variance experienced by customers. $(CR)^2$ will remove the variance in delivery time by forecasting at 100% accuracy when customers will receive goods.

CONCLUSION

In the current climate of downsizing in both manpower and inventory investment funds, it is crucial that we develop new strategies for maintaining our readiness posture. $(CR)^2$ will provide the solutions to current readiness issues and posture us to quickly respond in an ever changing global environment.

Reengineering Administrative Processes Using Bar Codes: Procurement

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ABSTRACT

FedEx and other private-sector overnight package delivery services could not achieve their level of service and profitability without using bar codes. Government managers and managers in private-sector companies can use the same technology to understand how work flows within their organizations. This technology aids organizations in developing process flow information and in business reengineering and streamlining administrative processes. We applied bar code technology to the procurement process of a medium sized nonprofit organization to test our premise that government and commercial operations can also benefit from that technology.

We reached the following conclusions regarding bar codes

- They are an effective tool for identifying and validating process flow steps.
- They provide the means for easily developing the database needed to generate a variety of on-line management performance reports.
- They save time and improve the accuracy of data entry.
- They are an effective device for tracking and locating documents.

We believe bar code technology can be equally effective when applied to other administrative processes.

INTRODUCTION

FedEx (formerly Federal Express) and other overnight package delivery services could not achieve their level of service and profitability without using bar codes. That technology has permitted them to maintain complete control of millions of items at all times even though many items travel thousands of miles each. Using the data generated from bar code readers, FedEx is able to track the locations of any of their packages at any time. Government managers and managers in private-sector companies can use the same technology to understand how work flows within their organizations. Additionally they can use bar codes to create a data base to support management reports and document control.

This paper describes the use of bar codes in the procurement process to increase managerial effectiveness and efficiency by providing better tools for controlling the flow of work. That control should also ensure optimal use of scarce resources. At the Logistics Management Institute (LMI), we recently completed the development and testing of a system using bar codes to track activities in the procurement process as a prototype for Federal agencies. That system serves as a test bed to determine the usefulness of bar codes for improving the ability of managers and their staffs to identify the work process flow and to streamline and simplify it, to improve the usefulness of the reporting system, and to continually track all documents.

In the past few years, many papers and books have been written on the need to perform work processes more efficiently and effectively. Michael Hammer, a well known author in the field, has been encouraging the reengineering of work, and one of his specific principles is to use bar coding (and other methods) to collect information once and at the source. [1] Hammer and Champy find that understanding the current process is critical to reengineering but that "what people tell analysts, however, is what they think they should be doing, what they happen to remember, or what they've been told to say; they do not tell what they actually do. What people do and what they say they do are almost never the same."[2] In several recent management studies, we noted that Federal agencies must understand their work process flows better in order to streamline them. We have applied bar coding as a tool to define the existing process more accurately.

Although understanding the process is the required underpinning for changing it, developing a work process flow and obtaining timing data on the completion of each step is an elaborate, time-consuming, and resource-demanding process. Managers often forego developing work process flows for administrative processes because of the difficulty in obtaining the required information. Therefore, if we could devise a method for developing accurate work process flows more readily, managers would probably make greater use of them.

Using bar codes is one means for obtaining accurate information easily to aid in developing process flow information and for business reengineering and streamlining. Bar codes allow managers to identify documents, track them, measure performance, and report with ease. The bar code report can be designed so that it highlights or sets a flag to indicate the need for an action. To be most effective, bar coding must be integrated with performance measures, whose standards can be built into bar code management reports.

Important advantages gained from the use of bar code technology are accuracy and speed, both of which contribute to cost-effectiveness. [3] When a data collection task has been performed using bar code scanners and laser wands, the data collection time is often reduced to 40-50 percent of that required for manual collection. In addition to saving time, bar coding eliminates errors. In bar code technology, "what you read, is what you get."

Our research to-date has been limited to the application of bar coding to the procurement process. We believe that it has similar application to such other administrative areas as contract planning, budgeting, and grants processing which may be subjects for future research.

HISTORY OF BAR CODES

The history of bar codes presented in this section is excerpted from Roger Palmer's book, *The Bar Code Book.* [4]

First patented in 1949, bar codes are a series of wide and narrow black "bars" and white spaces printed on a label. They are now widely recognized as the universal product codes (UPCs) read by scanners in retail stores. Bar code readers are optical devices for scanning bar code labels with a beam of light and converting the "on and off" light reflections to digital data. Since the early 1980s, bar code symbologies have been established as standardized codes that define letters, numerals, and symbols in terms of "bar" and space combinations on the bar code label. One common standard — the Federal Standard Bar Code (Code 39) — can interpret 128 different combinations of bars and spaces on the bar code label. These combinations can include the upper and lower case alphabet, numerals 0 to 9, plus various symbols and characters. Currently, efforts are directed at achieving higher densities of coded data on the bar code label.

The desire to automate supermarket checkouts drove the early technological development of bar coding. Wallace Flint, son of a Massachusetts grocery wholesaler, wrote his 1932 master's thesis at Harvard on a system for automating supermarket checkout counters. Flint's proposed system used flow racks and punched cards to dispense products to customers automatically. The proposal was economically unfeasible, but for the first time, the benefits of an automated checkout had been completely documented. Forty years later, Flint was the vice president of the National Association of Food Chains, and he actively supported the standardization effort that led to the Universal Product Code.

In the late 1940s, Joe Woodland and Berny Silver were investigating technical approaches that would allow prices of grocery items to be read automatically at the checkout stand. Several approaches were pursued, and their developments culminated in the filing of U.S. Patent 2,612,994 in 1949. Their patent describes a circular printed pattern that resembles a miniature archery target. The concentric rings of the target are, however, simply bars and spaces curved into a circular form. Conceptually, bull's-eye coding and bar coding are the same.

Serious efforts toward developing a standard for automating the supermarket point-of-sale began in 1968. RCA developed a bull's-eye symbol and scanner that operated in a Kroger grocery store in Cincinnati for an 18-month period beginning in 1972. This test store provided much valuable data for cost-benefit analysis and system refinement. Meanwhile, in mid-1970 a grocery industry ad hoc committee was formed. A massive symbol evaluation was undertaken that included laboratory tests by Battelle Memorial Institute, printing tolerance tests assisted by the Graphic Arts Technical Foundation, print ability tests by participating grocery manufacturers, and store tests of complete working systems. This effort concluded with selection of the UPC symbol as the industry standard on April 3, 1973. The early success of UPC in U.S. and Canadian supermarkets encouraged foreign, particularly European, interest in the system. This interest led to the adoption of the European Article Numbering (EAN) code and symbol in December 1976.

Industrial applications of bar codes can be traced to the early 1960s. In 1962 E.F. Brinker of Westinghouse Air Brake filed a patent that described a bar code attached to the side of a railroad car. Several companies pursued warehouse and related applications following the initial railroad experience. In 1971 the Plessey Company developed a bar code and reading system for library checkout. Codabar was developed by Monarch Marking Systems in 1972. These symbologies continue to be used in libraries and in blood collection applications.

During the 1970s, bar coding became increasingly practical and economical with the advent of low-cost electronics — microprocessors in particular — and the availability of smaller, lower cost lasers. As bar codes became technically and economically more viable during the 1970s, the UPC retail system provided stability and acted as a stimulus for industrial acceptance. In the late 1980s, refinement efforts were concentrated on nonconventional symbology that offers significant density advantages over more traditional bar codes.

APPLICATION OF BAR CODES

The use of bar code technology is limited only by the creative talents and initiative available to find its many applications. Its use can attain several objectives simultaneously. First, it is an excellent tool to use in establishing and validating work process flows. Second, it is an effective tool for aiding management in gathering and analyzing data. Third, it provides a fail-safe mechanism for tracking the status and location of all documents within an organization.

Data from bar codes can be obtained through the use of electronic scanning readers

rather than by keyboard or written entry, thus eliminating visual, typing, or other errors. Further, data entry with a scanner requires only a fraction of a second. The software used with bar coding also provides great flexibility by enabling users to change some or all of the recorded characteristics of a commodity or process. It does so by changing the record within the computer data base itself rather than by changing the affixed bar code label. For example, grocery stores often change the price of commodities on display. If the grocer wishes to change the price of a can of soup from $.79 to $.59 cents for a special sale the bar code label remains on the can of soup, to identify it as a unique item, and the computer data base is revised to reflect the price change. When the customer arrives at the check-out counter with the can of soup, the cashier scans the bar code, that information is automatically fed into the computer, and the revised price of $.59 cents appears on the cashier's display. The cashier does not need any technical knowledge of the commodity being scanned. The bar code label and the computer data base together provide the required information.

We developed and tested the use of bar codes so that we could fashion a credible tracking, measurement, and management tool that had many different administrative applications for potential users.

PROCESS FLOW

General

The first step in studying a process is to have the manager identify the types of actions that such a study can assist, e.g., procurements that require source selection, vendor deliveries, and invoices. The manager must then decide on a time period during which a statistically significant number of those actions will likely be completed.

Government contracting personnel are frequently overwhelmed by preaward actions and post-award monitoring responsibilities. In developing previous acquisition process flows, we noted the need to streamline those activities. Reducing the burden of routine document handling and tracking is an important contribution to both preaward and postaward activities. Issuing status reports for only those situations that are "out-of-tolerance" can substantially reduce the workload of contracting personnel. Establishing time standards for completing each activity that constitutes a processing step and integrating those standards into the reports prepared from the bar code data base are prerequisites to "reporting by exception."

The following six activities characterize the overall procedure we recommend to produce a process flow diagram and analysis for an operating component that has no current process flow diagram:

- Discuss the program and requirements, including the goals and objectives, with the client.
- Gather information from selected client personnel.
- Draft the process flow milestone steps and develop data collection forms.
- Collect and enter the data.
- Analyze the data and prepare the final process flow diagram.
- Integrate the results into a final report.

LMI Case Study

To provide a simplified system to reduce the work load of professional procurement personnel and improve their effectiveness, LMI undertook an independent research and development task to develop and test a tracking system based on using bar codes. Our purpose was to develop a bar code tracking model to aid in streamlining and simplifying the procurement process, improving the responsiveness of the

reporting system, identifying the location of all documents at all times, providing flags to indicate when an action must be taken, and fixing responsibility for each step in the process.

We developed and tested a bar code tracking system using LMI's in-house procurement office. We selected that office because it awards and administers both purchase orders and contracts and thus provides a representative contracting environment for the test. In our test, we assessed the feasibility and cost effectiveness of using bar coding techniques to track documents such as purchase requests, purchase orders, subcontracts, approval memos, deliverable reports, and invoices through all of the current administration steps. We also had the following objectives:

- To establish a process flow procurement model that can be readily expanded and applied to the more complex procurement environment of larger organizations.
- To develop reporting formats that can be displayed either electronically or in hard copy. The reports will be based on the concept of reporting by exception.

In the following paragraphs, we describe the hardware and software that we used, the methodology that we followed, the resultant products, and the test issues and their resolutions.

Hardware and Software

The following hardware and software is needed to implement a basic bar code system:

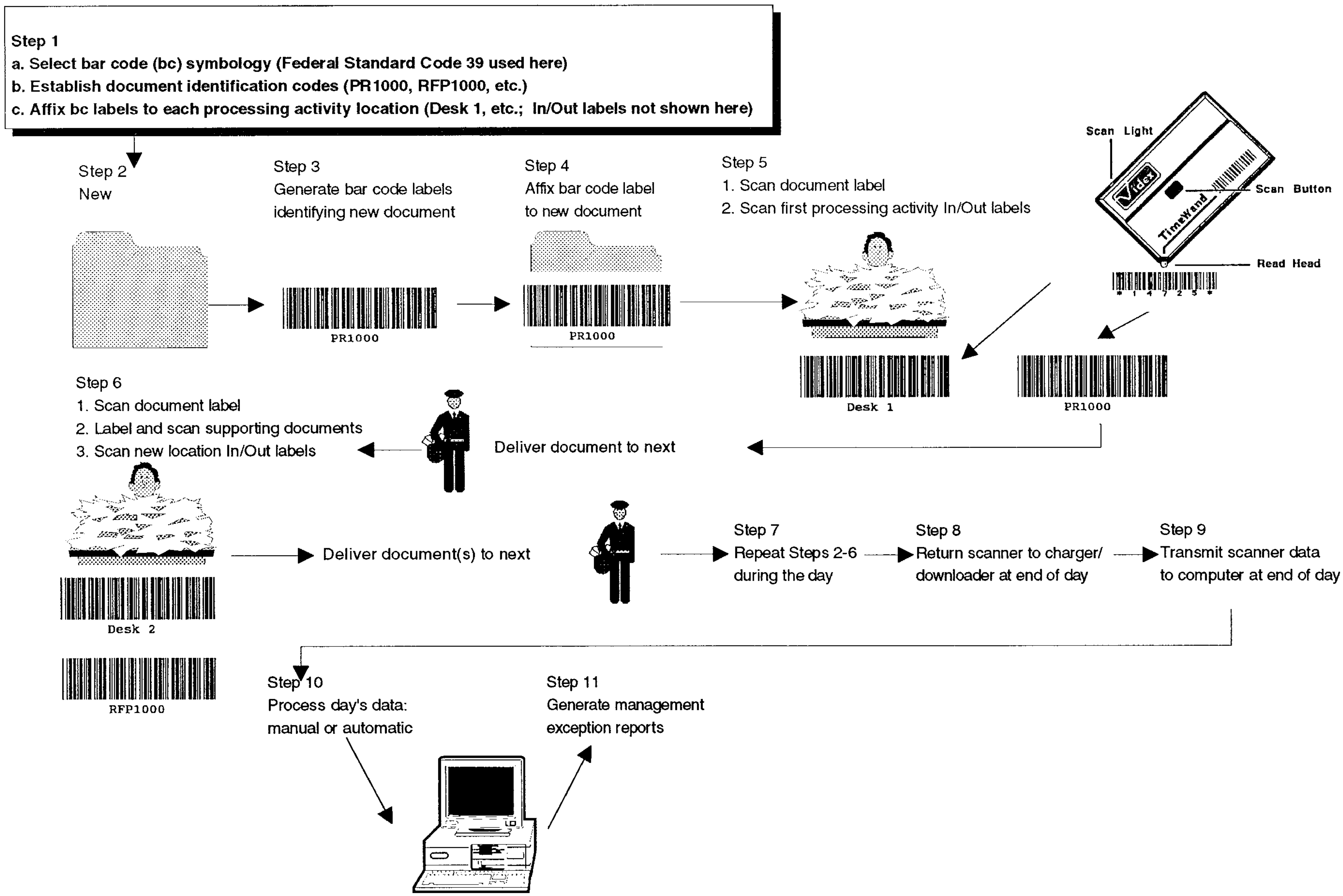
- A portable bar code scanner and software for programming it with the desired bar code symbology
- Software for generating bar code labels with the desired identification information
- A laser printer or a specialized bar code printer and labels
- Hardware for charging the batteries of the portable bar code scanner and a cable interface to a computer
- Software to transmit (download) data from the scanner to a personal computer (PC)
- Software to log incoming scanner data, process the data for tracking and time lapse measurements, and produce the required management reports either electronically or in hard copy.

A simplified process flow diagram for our bar code tracking procedure is shown in Figure 1. The three tasks outlined in Step 1 of that figure must be completed to select specific hardware and software before undertaking Steps 2 through 11. Some questions that must be answered when considering the selection of bar code symbology and the document identification protocol are as follows:

- Are the documents that are being tracked part of a larger system with a previously established bar code labeling protocol?
- Are alphanumeric rather than numeric designators required for adequate identification?
- Are printed text versions of the bar code required on each label for visual inspection?
- Is the label merely a tag for a specific document, or must it contain significant text and/or tabular information?
- Must document labels be generated on a unique, ad hoc basis, or are sequential generic labels sufficient for identification?

In the early phases of implementing a bar code tracking system, we found that flexibility

Figure 1. Bar Code Processing and Tracking Steps



in coding the information in the individual bar codes is useful (requirements for additional information always seem to arise during this period); we also found the need for flexibility in the procedures for downloading and subsequent processing the scanned data.

Those conditions put a premium on the availability of a dedicated PC and bar code (or laser) printer for all the coding and data processing steps. Fortunately, a simple MS/DOS or Windows computer and 300 dot per inch laser printer will operate the basic software required. In addition, even the simplest of bar code scanners can store several hundred bar code scans before its data must be downloaded.

Many combinations of hardware and software can be used with bar codes, and we do not recommend any particular manufacturer's equipment. However, in our test case, we used a portable hand-held bar code scanner with 8K of memory (sufficient to store about 500 10-digit bar code scans). We coupled the scanner and its battery recharger and data downloader station to an MS/DOS PC through a communications software package. We selected a compatible printing software package that operated on the same computer system as the scanner. The bar code symbols used in this project were printed on 1" × 2 ½" paper labels with a laserjet printer. Although many scanners, including the one selected, can process a variety of bar code formats, we used the Federal Standard Code 39 for all the evaluation tests. Figure 2 presents a summary listing of the bar code system elements used in our research.

Methodology

Our initial action was to document the actual steps in the procurement process, from the initiation of a purchase request through contract award and administration to closeout. We identified those individuals playing a major role in the procurement process, e.g., approving officials, project officers, and receiving, finance, and accounting personnel, as "processing activities."

Next we generated a bar code label to be affixed to each new incoming procurement request (PR) and to be read by a bar code scanner first when that request arrives at a designated processing activity and a second time when it leaves that activity. Each additional document generated internally in support of the incoming document (e.g., statement of work, evaluation plan) which is scanned in and out of each subsequent processing activity, has a bar code label affixed to it.

Third, we affixed a separate set of bar code labels to "In" and "Out" baskets at each processing activity's location as a unique identifier of each activity (even though, in a small office, a number of activities may actually be executed by one person at one location). For example, at

Figure 2.
Summary Listing of Bar Code System Elements

Type of equipment/software	Description
Portable scanner	Time Wand I, 8K memory, with charger/downloader; Videx, Inc., Corvallis, Ore.
Communications package	Time Wand I; Videx, Inc.
Bar code printing software	EZBarcode II; Time Keeping Systems, Inc., Cleveland, Ohio
PC	MS/DOS or Windows, 286 and above
Bar code printer	HP Laserjet III
Bar code labels	Avery No. 5160, 1" × 2½", paper

the first processing activity in Figure 1 (Step 5), the documents courier scans the in-basket label (for simplicity, only a bar code label called "Desk 1," "Desk 2," etc., is shown in the figure). The document courier also scans the out-basket label and any PRs or other labeled documents that are ready to move to the next processing activity.

Fourth, we provided contractors with a sheet of bar code labels that match the purchase order issued to them. We requested the contractor to affix one of those labels to each of their invoices, shipping documents, deliverables, or other related communications.

Fifth, we issued a set of labels identified as "Receiving" to the receiving department along with a copy of the purchase order. These labels were to be affixed to incoming contractor documents that the contractor failed to label as requested. We issued a set of labels identified as "Accounting" to the accounting department along with a copy of the purchase order. The accounting department was to affix those labels to the incoming invoice if the contractor had not labeled it as requested.

Resultant Products

We believe that the effectiveness of bar code technology for document tracking and data base generation can be more readily understood when we combine the results of the internal LMI process flow study of its procurement activities with similar studies that we performed at several Federal civil agencies. In the following paragraphs, we briefly describe our process flow work and how we have integrated bar coding applications into it.

A process flow diagram, in hard copy or in electronic format, is an evaluation tool that graphically maps the activities that make up a process. It is visual representation of the sequential and/or concurrent steps in a process, the interfaces that exist between organizational units involved in the process, and the time relationships of one step to another in the process. In developing process flow diagrams, LMI generates a series of linked "activity boxes" that contain the following elements of data relevant to each step in the process:

- Task Description — a brief description of the activity taking place at that step
- Task Number — an alphanumeric designator for the task description that permits easy sorting of similar tasks
- Start Date — the calendar date on which the specific step in the process begins
- Duration: Work Days — the time between the acceptance of the task in one step and the handing off of that task to the next step in the process
- Task Hours: Professional/Support/Contractor — the actual hands-on, or applied time for completion of the task for the three categories of labor
- Law, Regulation, Policy, Practice — the written or oral requirement for the specific step in the process.

In addition to Hammer and Champy cited above, other authors who discuss process flow in the contracting function are noted in "From Budget to Award: Acquisition Process Flow Analysis."[5] Once the existing process is known, we can begin the task of simplifying, streamlining, or business reengineering.

We found that in most procurement offices, a unique set of process flow steps that fit the specific operational requirements have evolved. We also found that while the number of steps and the language used to describe those steps differ from organization to organization, an underlying set of steps exists and can be used for comparison purposes. In this paper we use the "generic" set of steps we developed to illus-

trate bar code document tracking in a process flow environment.

Figure 3 identifies the 10 generic contract award process flow steps, each represented by a desk containing an "in" box and an "out" box with each having a unique bar code label identifying that step. Similarly, each document generated in support of the incoming procurement request (PR1000, CBD1000, RFP1000, to A/P1000) contains the bar code symbols that uniquely apply to each of those documents.

All bar coded documents in "play" at any time are monitored on an agreed schedule — usually daily — through use of a portable bar code scanner. Generally, in a small contracts office, one person, acting as a courier, is trained to operate the bar code scanner and is responsible for scanning the contents of each "In" and "Out" box at each processing activity location when an item is transferred to the next step by the courier. The scanned bar code data are downloaded into a PC where the data can be automatically processed into various reporting formats.

From the processed data, status reports can be tailored to the needs of each organization and can be prepared manually or automatically. Several such reports are described below under the application of bar coding "As an Analytical Tool."

Issues and Resolutions

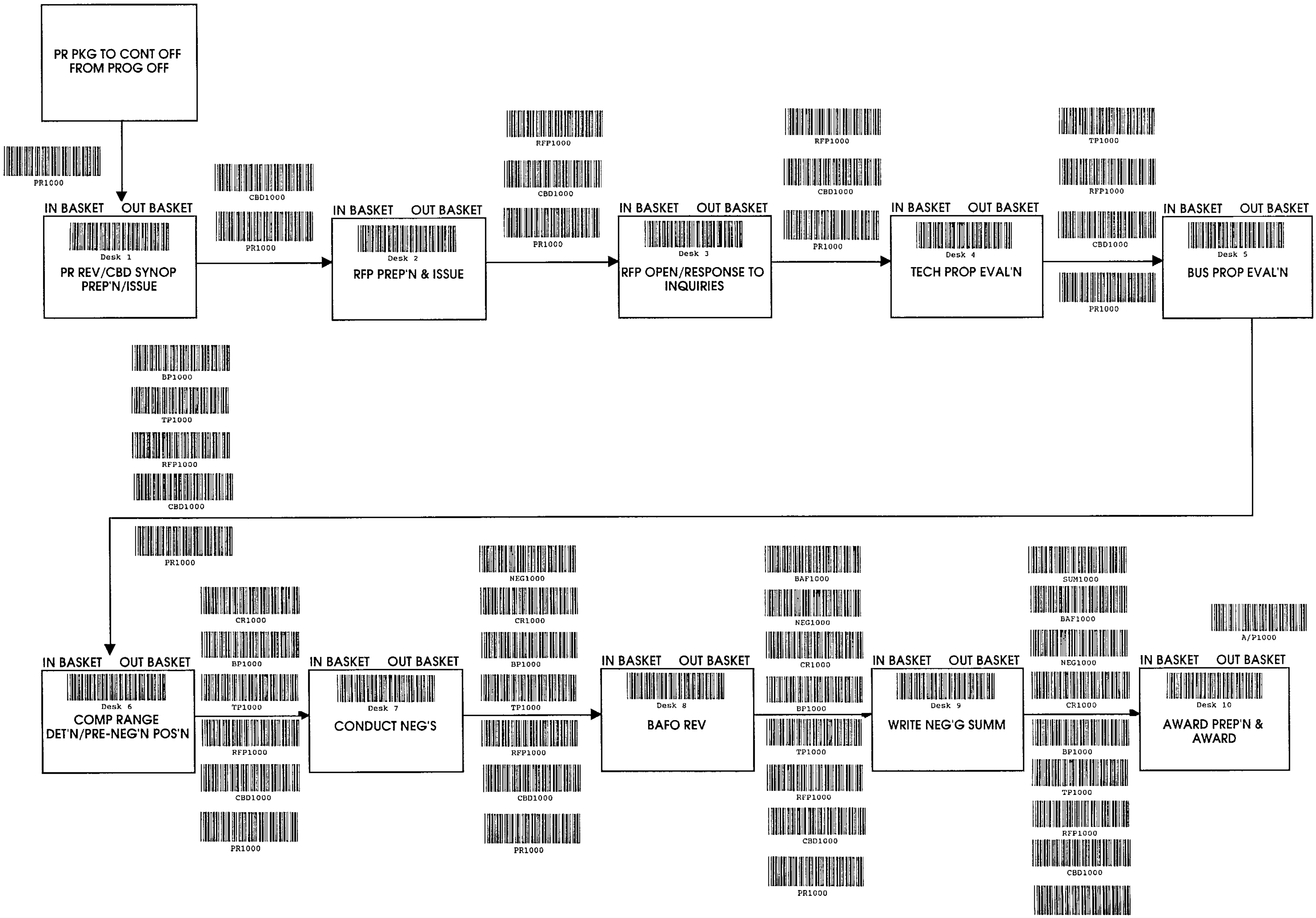
In this section, we describe some of the problems we encountered during the LMI case study and some solutions we believe should correct those problems.

We found it necessary to make several iterations in the contracting office's work process flow before we could bring perception into line with reality. This step took the most time. After we revised the existing process flow, the rest of the process of establishing the bar code tracking system fell into place. While the existing process flow must be understood prior to establishing a bar code tracking system, the actual implementation of the tracking system can be instrumental in helping to refine the accuracy of the process flow itself. Steps that are overlooked as well as steps that are seldom or never used become obvious. During the course of the test, we also subdivided a few steps that had initially been combined.

The initial test at LMI used a single person to perform all of the bar code reading for the entire process. That approach, while time consuming for the individual involved but not a severe problem, became a hindrance during busy periods. We estimate that at a maximum, the bar code reading added two minutes to some steps, especially if the purchasing professional forgets to log it in at the start of each processing step and if the bar code is not read on the day of receipt; both problems require manual corrections. The person who scans the bar code must do so in a timely manner in order to ensure accuracy in the time records. In a complete application, however, the bar code scanning would be done either by each person working on the document with her/his own reader as it was processed, or by a courier who moved the document from step-to-step during the process. The LMI purchasing professional estimated that a day or day-and-a-half would be required to learn the system.

Initially two sets of steps — one for purchase orders and one for contracts — were developed. However, since most of the steps were the same for each group, we decided to use only one set of 22 steps. Those steps comprise both contract award and administration. Therefore they are different from the 10 generic steps referred to in Figure 3 which contains only the contract award steps and does not include administration. During the test period, that combination of steps sometimes required the person doing the scanning to pause to reflect on the correct sequence to use in the case at hand. In a complete application, the processing steps for

Figure 3. Generic Contract Award Process Flow Steps for Bar Code Tracking



each type of action would be separately maintained.

The need for revising the steps in a complete application depends on the accuracy and completeness of the existing process flow, the number of changes that occur in the processing cycle, and the use of the collected information. The process flow we used for our test bed did not incorporate the steps associated with developing a request for quotations for subcontracts, nor did it provide steps for competitive actions or modifications to purchase orders. While their omission did not detract from our test results, in a complete application all significant steps should be included.

Some processing actions do not readily lend themselves to recording. For example, the furnishing of a service, such as for copier repair, does not produce an object that can be bar coded and scanned. As a result, the action will often be missed unless its scanning into the system is simulated. For example, "copier repair" could be recorded by scanning the bar code label from a master list of events.

The purchase order number is preferred as the tracking number. Thus, its bar code has to be assigned before the document is first read into the tracking system. This assignment can be made by obtaining numbers as needed from a central office or by having blocks of purchase order numbers assigned to offices in which documents are originated.

Once the purchase order has been awarded to a contractor, the name of the contractor should be entered into the tracking system, since the purchasing office typically tracks open actions by the name of the contractor.

In a small office, the most practical approach may be to print a complete set of labels for each action. However, when that approach is followed, the unused labels must be available until needed. We found that the sheet of unused labels could be retained inside the purchase order folder. In a larger operation that can support multiple printers, label storage is not an issue because the labels can be printed as the action occurs. Having multiple printers and the ability to produce labels on demand also solves the problem of needing extra labels for partial shipments or partial invoices.

Purchasing personnel may be concerned that the tracking system will be used primarily for monitoring individual performance rather than tracking the location and status of the purchase orders and contracts. If used for individual monitoring, they are concerned about who will determine the processing time standards and how they will be applied. By involving purchasing personnel when establishing these standards and their application, managers may help alleviate these concerns.

OTHER APPLICATIONS OF BAR CODING

Our overall purpose in developing and testing a bar coding system was to fashion a credible tracking, measurement and management tool that will have many different administrative applications for potential users and to build on our research and analysis on process flow diagramming. One of the primary benefits of bar code implementation is the creation of a data base that can be used to develop various management reports and for document control.

As an Analytical Tool

The data base can contain whatever elements managers desire, but usually data from bar code scanning contain the identifying number of the document and the dates the document entered and completed each step. On the basis of organizational requirements, users must establish the types and categories of documents that are to be bar coded. The extent of bar coding application may depend upon such considerations as the size of the office, its complexity,

the contracting volume, the number of individuals involved in the process, the size of the contracting staff, and the risk and cost of lost or misplaced documents. Once documents have been bar coded, they can be traced through the process.

Other identifying information may be useful in the data base; that information includes the originating office, the dollar value of the action, the type of item being purchased, the name of the company that was awarded the contract, and whether the company is a small business or minority firm.

The data base, in part, may be generated by scanning documents as they move through the process. Those data can be used to develop reports that can then serve as analytical tools. The reports only answer questions on timeliness; they do not provide any indication of why an event may have occurred when it did. The following types of reports might be generated:

- *Contract Process Flow Exception Report — Processing Days in Excess of Baseline Days*
- *Contract Process Flow Alert Report — Daily "Hot List" Action Report*
- *Process Flow Step Backlog Report*
- *Process Flow Variance Report*
- *Process Flow Elapsed Time Per Step Report*
- *Process Flow Completed Action Report.*

The following paragraphs present a discussion of the content and use of each of those six reports.

Contract Process Flow Exception Report — Processing Days in Excess of Baseline Days. A prototype of this report is shown in Figure 4. Preliminary standard elapsed processing times (baseline) for each step are shown in row 25 of Figure 4. At the bottom of Figure 4, for each processing step, we also show a range of days as "Standard Processing Window, Days" (Row 27). The elapsed time shown is the actual average time taken to complete each step based on our experience at a civil government agency. The numbers shown in the blocks in the body of the report are those *in excess* of the baseline for that particular action. This form of report enables contract professionals to focus their attention on contract actions or other administrative matters on an exception basis. If actual processing time is above the baseline (as indicated in Figure 4), the standard processing time is exceeded, and immediate corrective action should be taken. This method of progress monitoring provides various supervisory levels with an effective tool for managing the various stages of the procurement process or any other administrative activity.

Contract Process Flow Alert Report — Daily "Hot List" Action Report. Figure 5 is a prototype of this report. The report highlights for both the specialist and the supervisor that an action is approaching the processing time standard. Its purpose is to provide a daily alert that a contract action is coming due by flagging it before it reaches the end of the standard time specified for it. When an action has been in a step for 75 percent of the time specified as the standard for that step, it is flagged as a "hot list" action item. The report then displays the total elapsed time for that step. We recommend that responsible individuals view this report at the beginning of each working day. Having this information will permit them to take appropriate action before the standard is exceeded.

Process Flow Step Backlog Report. This report, which can be produced in several different formats, shows the number of contract actions in each processing step as of the date of the report. For an individual contract specialist, the report shows the current step of each action assigned to that specialist. A manager can view the workload of an individual, compare work-

Figure 4. Contract Process Flow Exception Report - Processing Days in Excess of Baseline Days (Prototype)

Microsoft Excel - 418KTRPF.XLS

File Edit Formula Format Data Options Macro Window Proof Help

A25 | Baseline Days

CONTRACT PROCESS FLOW EXCEPTION REPORT: PROCESSING DAYS IN EXCESS OF BASELINE DAYS

ACTION NO.	1. PR Review CBD Synopsis Prep'n/Issue	2. RFP Prep'n & Issue	3. RFP Open/ Response to Inquiries	4. Tech Prop Eval'n	5. Bus Prop Eval'n	6. Comp Range Det'n/Pre-Neg'n Pos'n	7. Conduct Neg's	8. BAFO Review	9. Write Neg'g Summary	10. Award Prep'n & Award
1000										5
1001								3		
1004									2	
1006									2	
1008										1
1010									3	
1012							10			
1016						3				
1018				9						
1021					6					
1027						4				
1028						1				
1033				5						
1039				5						
1044		2								
1052	5									
1059					5					
1068		15								
1075	1									
Baseline Days	21	27	35	23	9	9	7	4	8	9
Standard Proc'g Window, Days	16-21	20-27	26-35	17-23	7-9	7-9	5-7	3-4	6-8	7-9

Normal

Ready NUM

Figure 5. Contract Process Flow Alert Report - Daily "Hot List" Action Report (Prototype)

Microsoft Excel - KTRACTON.XLS

File Edit Formula Format Data Options Macro Window Proof Help

A27 Window, Days

CONTRACT PROCESS FLOW ALERT REPORT: DAILY "HOT LIST" ACTION REPORT

ACTION NO.	1. PR Review CBD Synopsis Prep'n/Issue	2. RFP Prep'n & Issue	3. RFP Open/ Response to Inquiries	4. Tech Prop Eval'n	5. Bus Prop Eval'n	6. Comp Range Det'n/Pre-Neg'n Pos'n	7. Conduct Neg's	8. BAFO Review	9. Write Neg'g Summary	10. Award Prep'n & Award
1002										7
1005										7
1007									6	
1009									8	
1014								3		
1019							7			
1025							5			
1031						9				
1042					9					
1050					7					
1063				17						
1065			35							
1072		20								
1078	16									
Baseline Days	21	27	35	23	9	9	7	4	8	9
Standard Proc'g										
Window, Days	16-21	20-27	26-35	17-23	7-9	7-9	5-7	3-4	6-8	7-9

Normal

Ready NUM

loads among specialists or for the office as a whole, and view a summary of the workload and current process step for each contract action.

Process Flow Variance Report. This report shows the actual processing time of each step for each contract action and the amount of variance from the baseline standard. Those times that are either above or below the standard by more than 10 percent are highlighted in bold. With that information, managers can then look for the common elements that such actions might have — for example, they may be more complex, larger than average, processed from one office or by the same person, etc. — and take appropriate action in areas that offer the highest potential for streamlining the process.

Process Flow Elapsed Time Per Step Report. This report is similar to the *Process Flow Variance Report* except that it shows total elapsed time for each step rather than the variance from the baseline. Some managers may find this report more useful in reviewing the validity of the baseline time standards for each process step.

One of the key performance measures commonly used in procurement processing systems is the administrative lead time, that is, the actual amount of time it takes between receipt of the procurement request and contract award. The data base generated by the bar coded documents provides a readily available source of elapsed time measurements for managers. They can study overall processing time or the time it took each document (or all documents or the average document) to clear each step or a particular step.

Process Flow Completed Action Report. This report provides an historical record of all contract actions processed by the contracting office during a specified period of time. For those actions, it shows the actual number of days that were spent in each step and the total amount of elapsed time for each between receipt of the purchase request in the contracting office and contract award.

By using the bar code tracking data described above and depending on the identifying information that managers decide to incorporate into the data base, other reports can also be prepared. Examples of some other reports that can be generated from this data base are:

- *Small/Disadvantaged Business Action Report*
- *Competition Report*
- *Reports on Process Timing by Originating Office, Size of Action, Complexity, etc.*

Bar codes are most easily used to collect data on the elapsed time between steps. In some cases it may be possible to collect information on the hands-on time that is spent to complete the action. Those data will be available if each person working on the document uses the bar code scanner to log the time of starting and the time of completion (or interruption) for that work session.

Usually, comparing an office with itself over time provides more useful data than comparing it with other offices. Such self-comparisons eliminate differences in workload, procedures, equipment, etc., that may affect processing times, particularly when such differences are not well understood by workers, office managers, or higher level managers.

Application of Bar Coding to Document Control

In addition to using bar code technology to assist in developing process flows and as a management analysis tool, such technology is easily used to assist in document control. During the several-month period involved in the contract award process, managers often lose track of where the pending action is in the process. When follow-up requests are made, it is

often time consuming to identify the exact location and status of a particular action. Bar coding provides a better way of maintaining control of in-process acquisition actions.

As previously mentioned, the data base can contain whatever elements managers desire, but they must establish the types and categories of documents that are to be bar coded. Again, the extent of bar coding application depends upon the size of the office, its complexity, the contracting volume, the number of individuals involved in the process, the size of the contracting staff, and the risk and cost of lost or misplaced documents. Once the documents have been bar coded they can be traced through the process.

Since a document's bar code is scanned each time it moves from one process step to another, its location is readily available in the data base. Should one scanning be overlooked, the subsequent scan will identify its current location. Thus, any time information on the current location of a particular document is desired, it can be easily retrieved from the data base by using the *Process Flow Document Location Report.* Upon entry of a bar code or other identification of a document, this report will display the current location of the document.

A manager may also use the data base information to check on how many documents are at a particular location. By early identification of bottlenecks, managers can direct resources to correct the situation.

CONCLUSIONS

In this research effort we applied bar code technology to the contract award and administration process. The premise of our research was that such technology had served the users in commercial applications well and could similarly be a useful tool in analyzing the internal administrative operations of government. We found the technology to be useful in process flow diagramming and analysis, as an analytical tool, and for document control. In addition, we draw the following conclusions:

- *The use of bar codes is an effective tool for validating process flows.* Some basic information must be used as the starting point in documenting process flows. Since "What people do and what they say they do are almost never the same," [2] the discipline and accountability that bar code technology imposes in tracking documents through each process step into the data base quickly reveals to the work force the steps that were overlooked when the process was initially described. It also highlights that some steps are no longer valid from the initial process flow because bar code data cannot be collected on steps that are no longer operational.
- *Bar codes provide the means to easily develop the data base needed to generate desired management reports on the elapsed time spent in any step in the process, either for individual actions or for a group average.* The data can also be used to flag both "hot list" action items and overdue actions or other variations from standard processing times.
- *Bar codes enable managers to know at any time the location of each action under their responsibility.* This benefit alone avoids the periodic major "search for the lost document" activity that wastes so many staff hours.

Having successfully implemented bar code tracking in a small test bed operation, the next step is to evaluate and document both contract award and postaward contract administration processing steps in a large organization. This test will include establishing step-to-step processing time standards from a selected sample of actions. We can measure each new transaction

against the established standards and generate timely reports for those actions that are at or approaching out-of-tolerance status. We can also maintain a near-real-time record of each document's location in the process flow.

As a result of our research efforts, we have shown both the feasibility and benefit of using bar coding technology as an effective management tool either for validating process flows where they exist or diagramming them where they have not been previously documented. It also serves as an effective management tool and provides managers with a capability for easily locating documents. Now that we have demonstrated the applicability of bar code technology in one administrative process at one location, we are confident that it can also be applied to other similar types of administrative processes as well. We intend to expand our research efforts along such lines.

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MANAGEMENT DECISION/INFORMATION SUPPORT TOOLS

A GROUP SYSTEMS TOOL FOR STRATEGIC PLANNING IN CONTRACT NEGOTIATION

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DEFENSE SYSTEMS MANAGEMENT COLLEGE

ABSTRACT

This paper presents the results of research into the development and application of a computer-based aid to the contract negotiation team process. The tool that is presented by the authors is specifically designed for the first phase of the negotiation process, wherein the focus is upon fact finding and on setting negotiation strategy. It is in the fact finding phase that information is obtained which provides the underpinning for susequent development of contract negotiation strategy and the ensuing prosecution of that strategy. Reported in the paper are preliminary research results obtained from student negotiating team utilization of the subject tool in a complex multi-attribute negotiation simulation conducted a number of times during the past three years. The results to date indicate a substantial improvement in: (1) the individual negotiant's early perception of the structure of the negotiation armature; (2) the early apprehension of the critical as opposed to the minor negotiation issues; (3) the the nature and orientation of negotiating team posture on critical issues vis-a-vis individual team member alignments; and (4) individual understanding of the negotiation force field and its relationship to the negotiation clock and the associated issue-time probabilities. A preliminary finding is that these improvements lead to a decrease in the time it takes teams to negotiate complex issues, coupled with a corresponding increase in the Post-Negotiation Satisfaction Scale ratings as expressed by the participating negotiants.

If this paper is approved for formal presentation, it is the intent of the authors to demonstrate the tool in the context of a mini-negotiation simulation offered for attendees during the paper presentation session.

INTRODUCTION

This tool falls into the category or class of aids that map the collective perceptions of task teams as they work to attain performance objectives. These tools generally represent individual as well as summative understandings, and are usually designed to aid teams in reaching concensus and in subsequently developing performance strategies that will be both individually and collectively pursued. Tools in this group tool class nearly

always present information on the relative alignment of the team with respect to perceived variables of interest. Presentations of this nature catalyze group exploration of differences in alignment and create a baseline which is frequently a condition precedent to increasing group alignment and, accordingly, cohesion.

The tool developed during this research is unique in that it also provides a dimensional comparison that correlates directly with (1) the perceptions of the same variables by another (competing) group; and (2) a perceptual profile whose patterns and clustering relationships provide indicators that point directly to the "most likely" psycho-social path of the subsequent negotiation, the allocation of time afforded the various negotiated issues by the negotiants of both teams, and the issue priorities that will susequently focus and drive the negotiation process.

TOOL APPLICATION

A graphic representation of tools outcomes is shown in figure 1. The research protocol has been as follows: negotiant teams come together in a group systems environment after several hours of collecting data in fact finding, but prior to the opening negotiation session. The teams are generally composed of defense industry and Department of Defense mid-career acquisition professionals, some of whom have one or more years of defense acquisition negotiating experience. The team members have never previously been a member of the same negotiating team and thus are newly associated with each other in a negotiation team environment. Each team--in a separate session--is asked to collectively decide what factors or issues are to be negotiated. In point of fact, the primary issues are given to each negotiant as part of the negotiation simulation process (they are directed to negotiate a certain set of issues by higher authority). However, the simulation allows minor negotiation issues to be added as part of the team-developed negotiation strategy. Each individual team member, as hosted by the group system hardware and software, is then invited to rate on a scale of 1 to 10 (10 = Most Important) the Importance of each identified Negotiation Factor (issue) to: (1) the individual making the rating; and (2) the other (opposing) negotiating team. A similar rating using a comparable scale (10 = Most Flexible) is then used by the individual negotiation team rater to rate the same Negotiation Factors (issues) in terms of the perceived Flexibility of position of: (1) the individual/team of the rater; and (2) the other (opposing) negotiating team. Finally, a determination of "The Likelihood Of Reaching Agreement" is made by each negotiant using a linear probability scaling gadget (10 = Certain/Highly Likely, 1 = Highly Unlikely/Won't Happen) embedded in the group systems software. The results are

aggregated by the group systems software and presented to the group on a common screen similar to figure 1. A discussion of the significance of the clustering patterns of negotiation factor perceptions and their relationships and relative positioning then ensues, facilitated by the researchers. Implications of the outcomes on negotiation strategy are highlighted, and the teams discuss and realign their strategy based on the findings and implications the tool application outcomes provide. This process is then repeated by the other (opposing) negotiating team members.

The negotiants then--after a suitable interval--come together in a neutral negotiating space and negotiate to consummation (to date, 94% of all teams negotiating the factors in the simulation have reached agreement in the allocated time) a 5-factor contract negotiation utilizing the developed strategies and the Phased Negotiation Technique. The total negotiation process, including the fact finding period, is not allowed to exceed eight hours. Each phase in the negotiation is followed by a facilitated unpacking exercise in which a large screen video playback of the performance of the two teams in the previous phase is observed by the two teams and analyzed for gambits; strategy; communication via body language; micro-expressions in the face; tone, pace, and substance of voice; meta-language (what is not said); good negotiation style and technique; and other analyses of both individual and group performance. The teams then retire to separate spaces to realign their phase strategy to the outcomes of the previous phase.

The improvement in negotiating performance is substantial following the first unpacking exercise, and continues at a monotonically decreasing pace after each phase of the negotiation and its trailing unpacking process.

A total of 36 teams have participated in the negotiation scenario since 1986. Eight teams have participated in the scenario aided by the use of the group systems-based strategic negotiation planning tool. The relative performance of the negotiant teams in both a tool-augmentation and non-tool aumentation mode is shown in figure 2. Examination of this data suggests that use of the tool yields an average reduction of 40.5% in the number of negotiating sessions (phases) required to reach agreement on the same set of five complex negotiating factors: (1) price/costs; (2) schedule of delivery of multiple items in multiple months/years; (3) delivered quantities; (4)warranty provisions; and (5) rights-in-data. This reduction in the number of discrete negotiating events is accompanied by a mean reduction in time to reach agreement of 36.8%. The target price/cost of the resultant agreement, however has been found not to change significantly from that obtained in the non-tool augmented mode.

The average negotiated contract price is $58.2 M for all teams

negotiating to agreement, and $58.5 M for teams who utilized the group systems based strategic negotiation planning tool; the difference is not considered to be statistically significant for the indicated sample size. Finally, anecdotal evidence from an exit survey of negotiant satisfaction with the outcome of the negotiation process indicates a moderately higher degree of satisfaction with the negotiation for those individuals/teams who have used the tool. approximately 92% of all negotiants using the tool during the negotiation process profess satisfaction with the negotiation process itself and its outcome. This compares favorably with a satisfaction percentage of approximately 83% for those negotiants not exposed to the tool.

TOOL DISPLAY INTERPRETATION

The interpretation of figure 1 forms a portion of the facilitated and interactive post-application process that follows the group systems tool session. The following discussion refers to the display tableau of figure 1, the perceptual team map of negotiation issues.

The upper left hand quadrant of the display contains those negotiation factors that will be most influential in shaping the negotiation process and content. In classic negotiation terms, these are the potential "sticking points of the negotiation. The factors in this quadrant are perceived and rated by each team as inflexible in negotiating position and of relatively high importance. Factors in this quadrant can be expected to consume a major portion of the negotiating time if certain conditions exist. Further, factors in this quadrant are often submerged early in a negotiation, surface "mid-negotiation", and from that point on are experienced predominately as the focus of the negotiation.

The upper right hand quadrant of the tool display contains the next most influential negotiation factors. These factors are perceived to be of relatively high importance but the negotiating stance of the team is perceived as being one of relatively high flexibility. In the argot of professional negotiators, these factors are called "sweethearts", because they can and will be agreed upon early in the negotiation process, and provide psychic motive force that can successfully move a negotiation through its early stages if they are present in the issue/factor menu. Factors in this quadrant often provide opportunities for establishing a climate of success in a negotiation if certain conditions exist.

Factors located in the lower right hand quadrant of the tool tableau of figure 1 are the next most influential set, are perceived to be of relatively low importance by the rating negotiation team, and are seen to possess a positional lack of flexibility. Professional negotiators call these negotiation factors "add-ons". These factors are often tossed in to a negotiating milieu late in in the process with a "take-

it-or-leave-it" proviso, or used in a feinting gambit that attempts to give an incorrect impression of their relative importance mid-term to late-term in a negotiation. They are primarily used as the coin of psychological equilibrium by one side or the other, depending on whether certain conditions exist or not in the mid to late stages of a negotiation. They are rarely introduced as the momentary focus of a negotiation early in the negotiation process.

Those factors located in the lower right hand quadrant of the tool tableau are perceived by the rating negotiation team to possess relatively low importance but a negotiating stance of relatively high flexibility. Professional negotiators have labeled factors in this quadrant set "sweeteners or leaders". Focus on these factors may occur at any time position in the negotiation process, depending on the negotiating climate and gestalt of the individual negotiants at the moment of factor introduction. A common experience in negotiation is to observe that these factors are introduced early (as "loss leaders") or mid-term to late-term in a negotiation, in which case they are often used as "sweeteners" (to maintain or attempt to obtain psychological equilibrium mid-term), or as "closers" late-term, in an attempt to "seal the deal". Again, certain circumstances well known to seasoned negotiators mitigate against, mediate, or prompt their application in the various phases (phased negotiation) and stages of a typical negotiation.

The simplified interpretation of the relative clustering of a negotiating team's perceptions of the flexibility-importance continuum of negotiation involves factors of self as opposed to that of the opposing team, as follows: (1) Team factor perceptions of group "self" and of the opposing team that lie in the same quadrant increase the probability of agreement. Those clusterings of the same negotiation factor that lie in different quadrants are a cause for strategic concern.

If the differences are only between the lower quadrants, this is seen to inform the timing and conditions for introduction of these factors.

If the differences are perceived to lie only between the right hand quadrants, this is seen to inform not only timing but the negotiating gambits one might entertain with respect to these factors, and the gambits and timing one might expect to be pursued by the other (opposing) team.

If the single-factor differences lie in the left hand quadrants, this is seen as an indication of the potential for deadlock in the negotiations, via interaction on factors of relatively low importance to one of the negotiating teams. Thus, this pattern is an indication thata unique set of stratagems designed to break this unbalanced axis should be included in the negotiation plan.

If the factor differences indicated on the tool tableau are in the upper quadrants,

this is seen as the true focus, or armature, of the negotiation process (possessing the highest probability of deadlock but with high importance to both sides of the negotiation) and requiring the greatest amount of planning and contingency analysis; both to avoid deadlock and to increase after-negotiation satisfaction with both the outcomes of the negotiation and the negotiation process. It is postulated that higher satisfaction in these two areas will increase the probability of both: (1) attainment of sufficient consideration (economic and psychological) for performance of the agreement by both sides; and (2) after-the-negotiation performance on the terms of the agreement by both parties to the negotiation.

The analysis provided by application of the tool thus has provided insights about timing, focus, emphasis, factor-gambit matching, team alignment (provided by the group systems software statistical measures of the dispersion of individual responses, etc.), contingency planning needs, etc. of the upcoming negotiation. This information is a necessary precursor to the deep strategy development that is the hallmark of world class negotiation preparation in any venue.

CONCLUSIONS/SUMMARY

The tentative conclusions to be drawn from the results obtained to date from this research are as follows: (1) Time to successful conclusion of a typical (simulated) complex team negotiation of the type encountered in defense acquisition may be significantly reduced if a perception mapping tool such as that utilized in this research is applied during the early stages of the negotiation process (ie-in fact finding); (2) The number of negotiating sessions necessary to reach agreement in a negotiation of the type referred to above may be significantly reduced through utilization of a perceptual mapping tool early in the negotiation process; (3) negotiant satisfaction with both the negotiation process itself and the negotiated outcome may be increased via utilization of a perception mapping tool such as that employed in this research.

The defense acquisition process is arduous and costly. The contracting portion of that process is inordinately expensive and time consuming. Though implementation of the changes mandated by acquisition reform initiatives will certainly remove barriers to contract performance on both sides of the negotiating table, said reforms may not improve the efficiency and effectiveness of the contracting process as much as direct improvements in the contracting process itself. A simple and effective way to improve process performance may be the introduction and widespread utilization of tools such as the one employed in this research.

There are a number of questions that have arisen as a result of the work described in this

paper that may be the focus of future research. One question that particularly intrigues the authors is the exploration of the possibility of joint team sessions using this tool or one of similar design. Would joint sessions, with their potential for tableau overlay and simultaneous multidimensional analysis of both the perceptual framing (afforded by the current tool design) and the additional comparison of other (opposing) team perceptual accuracy, etc., further improve negotiation efficiency and effectiveness ?
What would be the affect on after-agreement performance ? Upon negotiant satisfaction ? It is the intent of the authors that these and many other such questions be the subject of future research.

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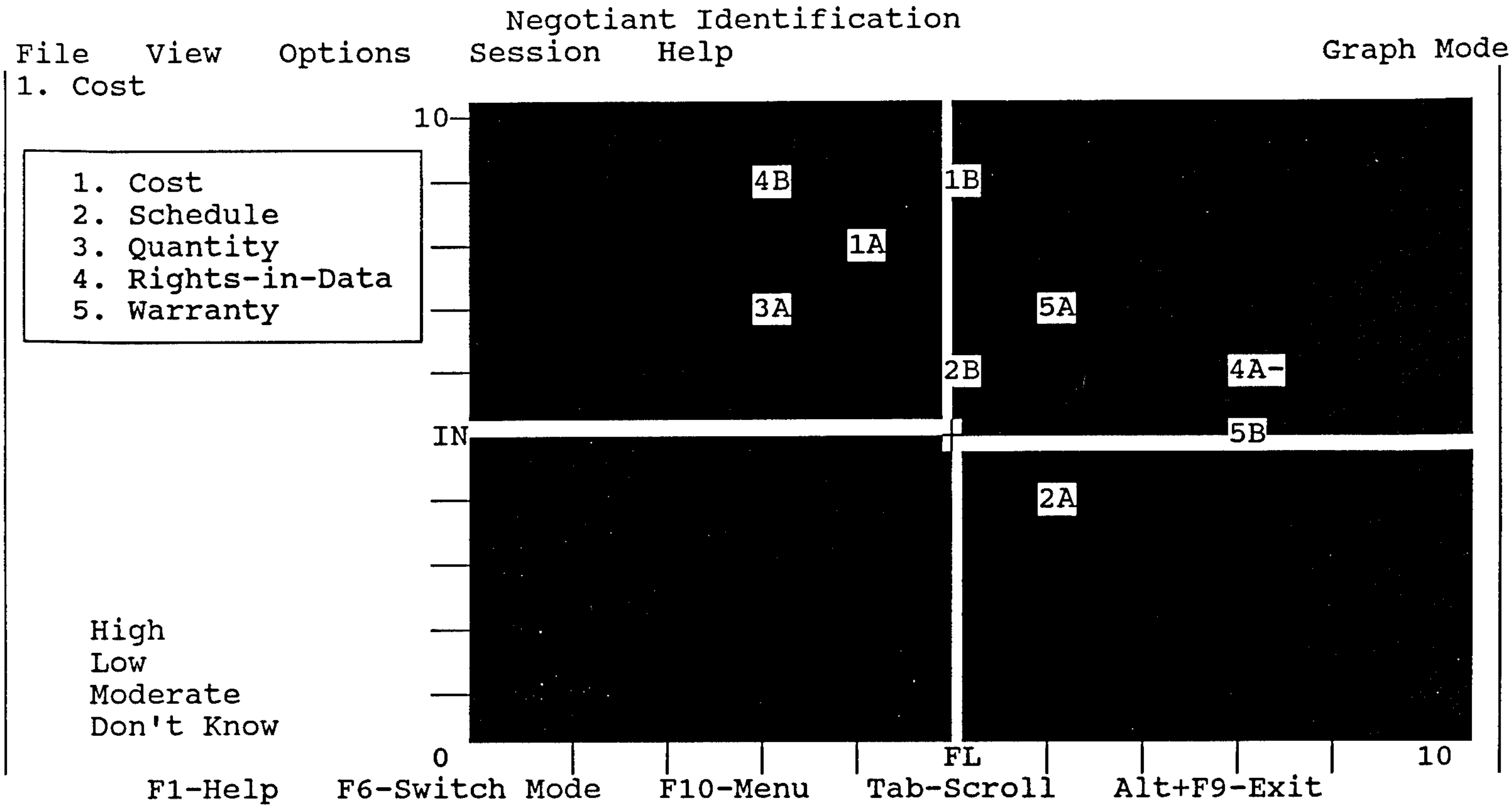


Figure 1

NEGOTIATION PERFORMANCE ANALYSIS

PERFORMANCE METRIC	TOOL USE	NO TOOL USE
Number Of Negotiating Sessions (Phases Req'd To Reach Agreement)	3.7**	5.2*
Time To Reach Agreement (hours) (Includes All Pre-Negotiation Activity)	6.25**	8.55*
Negotiated Contract Price ($M) (One Of Five Negotiated Factors)	58.5**	58.2*
Participant Satisfaction (% Sat) (Scale: Sat; Mod. Unsat; Unsat) (Satisfaction: Process <u>And</u> Outcomes)	92**	82*

Sample Size: 38 Teams
*No Tool Use: 30 Teams
**Tool Use: 8 Teams

Figure 2.

TECHNICAL SCREENING EXPERT SYSTEM TSES

Jane Lange and Brenda L. Kish

ABSTRACT

HAZARDOUS MATERIAL MANAGEMENT/ENVIRONMENTAL ISSUES are identified in the Navy Supply Corps Newsletter of September/October 1993 as PREEMINENT ISSUES...." an area of increasing responsibility for Supply Corps Officers....we must provide the POLICY, TOOLS, and TRAINING which position us to be the provider of choice for these services to both the Fleet and shore stations". This paper focuses attention on the need for effective POLICY, TOOLS, and TRAINING necessary to create a viable program to meet the challenges mandated by the Navy's concern for personnel safety and the environment. The Technical Screening Expert System (TSES) responds to this challenge by providing a tool which assists in the implementation of the Chief of Naval Operation's (CNO's) Hazardous Material Control and Management (HMC&M) Policies in an easy-to-use system which can be accessed worldwide. Our implementation plan includes installation of TSES on every ship in the fleet and shore-based activity, providing logistics support in the procurement, distribution, maintenance, and replacement of hazardous material. It further relates how TSES implements CNO's HMC&M policies and identifies the environmental advisories, directives, instructions and regulations which are incorporated into TSES. Furthermore, this paper explains how TSES fits into the realm of the HMC&M Program.

INTRODUCTION

On 26 July 1971, a Presidential Executive Order (E.O. 11612) entitled "Occupational Safety and Health Programs for Federal Employees" was signed. This Executive Order stated that the Federal Government, as the nation's largest employer, has a special obligation to set an example for safe and healthful employment. During the past 10 years and through several revisions of this first E.O., the Department of Defense (DOD) has issued many directives and instructions relative to implementation of the Navy Occupational Safety and Health Policy.

Consistent with this policy, TSES was developed as a Naval Supply Systems Command (NAVSUP) Small Business Innovative Research (SBIR) Project to assist ship and shore activities with implementing the CNO's HMC&M Program. TSES provides advisory support to technical and procurement personnel via a step-by-step logic guide, and affords users requisition guidance and restrictions applicable to both stock-numbered and

non-stock-numbered items, ranging from hazardous and non-hazardous items to plastic alternatives to medical/dental allowances. TSES incorporates 6 resident databases and accesses one external to the TSES software package. TSES also has the capability to link with other data information modules, and to automatically generate letters and forms relevant to the Hazardous Materials Program.

TSES incorporates program modifications based on user experience and feedback from on-site demonstrations and training, not only in the use of the system, but in environmental policy, regulations, and restrictions. Since its inception, over 200 system enhancements have been integrated. TSES is proving to be a dynamic, flexible, and viable tool for the requisition processor.

PROGRAM DESCRIPTION

The following chart, Figure 1, depicts the path a requisition follows as it is processed through the TSES software program. As the user inputs data, the system queries for additional information according to the type of requisitioned material. Therefore, all questions in Figure 1 are not applicable to every requisition. As the user answers questions, the system responds with invaluable advice/guidance and environmental restrictions applicable to both stock-numbered and non-stock-numbered items to enable the user to comply with the Navy's HMC&M Program. All acronyms in Figure 1 will be explained further in subsequent sections of this paper.

TECHNICAL/PROCUREMENT SCREENER

INSTALL
(requires 10 MB of hard disk space, approximately 450 KB of free RAM, and DOS 3.3 or above)

HELP TUTORIAL USER'S MANUAL
(help is available with F1 key, tutorial and user's manual are available from the main menu)

(SHIP) REQUISITION (SHORE)

TSES

INPUT REQUISITION, LSN/NSN, CAGE, P/N, ITEM NAME

SEARCHES DATABASES

LOCAL NON-STD SHML AMAL/ADAL AUL PRIME

FOUND

PRINTS ADVISORY MESSAGE AND TECHNICAL SCREEN SUMMARY

NOT FOUND

QUERIES FOR INFORMATION

ENTER FSC:

HIGH VOC/LEAD?
(specific FSCs)

HAZARDOUS? Y/N

AUTHORIZED? Y/N

87 RECEIVED? Y/N (shore)
(Generates Letter/Form/Instruction)

SFR RECEIVED? Y/N (ship)
(Generates Letter/Form/Instruction)

UPDATE LOCAL? Y/N

UPDATE LTR/MSG? Y/N
(Generates Letter/Form/Instruction)

PRINTS ADVISORY MESSAGE AND TECHNICAL SCREEN SUMMARY

Figure 1 TSES PROGRAM DESCRIPTION

TSES DATABASES

Countless hours of research are required to process a requisition. The technical/procurement screener searches file drawers full of old paper messages and pages through cumbersome technical manuals that are sometimes difficult to read. In all likelihood these same items were previously researched by another screener. Thanks to TSES, those days are over! Research is now at the screeners' fingertips in the form of 7 databases, as explained in the ensuing paragraphs:

Non-Standard: A database designed to allow the TSES user access to hazardous and non-hazardous non-stock-numbered data from all users. TSES has sufficient procurement and technical data fields to accommodate the Inventory Control Point (ICP) database and to be the vehicle that the fleet and shore activities can use to interactively obtain and provide technical data during the requisition screening process. The information is gleaned from data sent to NSPCC via automatic data input by users into their local database during the screening process. During this process, TSES generates a letter to NSPCC requesting this data be input into the Non- Standard database. This letter/data can be printed to a file and disseminated via the Stream-lined Alternative Logistics Transmission System (SALTS)/MODEM/DISC. Upon receipt of user data, NSPCC verifies the information, adds it to the Non-Standard database and redistributes the information to all users on a quarterly basis.

Plastic Removal In Marine Environment (PRIME): Plastic and plastic-containing items create an environmental hazard, especially for ships at sea, their personnel, and marine life. Therefore, NAVSUP researches and maintains a list of non-plastic alternatives. This information is found in the NAVSUP "SHIP's GUIDE for SHIPBOARD SOLID AND PLASTICS WASTE MANAGEMENT", Appendix A. TSES' PRIME database matches this data and displays the non-plastic alternatives upon entry of a National Stock Number (NSN) from the PRIME database.

Ships Hazardous Material List (SHML): It is extremely important for ships to protect their personnel from harm caused by hazardous materials and minimize the quantity of hazardous waste generated in day-to-day operations. Therefore, the SHML was developed to help the user ascertain if an item is allowed onboard. Five (5) APRON codes comprise the authorization field. "A" indicates an item is Authorized, "P", Prohibited, "R", Restricted, "O", Obsolete, and "N", Not Determined. The SHML also includes a Replacement NSN field and an Ozone Depleting Substance (ODS) field, identifying items containing ODS. This database is maintained by the Environmental Control and Packaging Programs Division at NSPCC and is updated quarterly.

Authorized Medical/Dental Allowance Lists (AMAL/ADAL): Updated quarterly by the Naval Medical Logistics Command, Fort Detrick, MD, these lists comprise NSNs of medical items which are allowed onboard. Classes of AMALs/ADALs,

described in the Help screen, further delineate these lists.

Hazmat Local Authorized Use List (AUL): TSES offers, for the first time, a standardized AUL format for shore activities. More significantly, it provides a means of developing local HazMat AUL databases and controlling hazardous material procurements when implemented as part of the technical screening and/or procurement process. NSPCC converts this data into the TSES format and returns to the cognizant user activity.

Local: Maintained by each user activity, the Local database allows the user to take those old paper messages from his file drawer and automatically load them into TSES during requisition processing. This saves the user countless hours of searching for previously researched information, permits the user to share data with other screeners at his activity, and ultimately to share data with screeners at all user activities via input into the Non-Standard database by NSPCC.

Hazardous Inventory Control System (HICS): An item which is stocked in the user's Regional HAZMIN Center is identified to the technical screener when TSES finds it in the external HICS database and refers the requisition to the user's HAZMIN center.

SYSTEM CAPABILITIES/FEATURES

LAN Compatible: TSES is local area network (LAN) compatible, offering multi-user access to databases. This eliminates the redundancy of several screeners researching the same requisition. After automatic input from the requisition screening menu, all local users can share the information.

Integration via HotKey User Menu: TSES offers the powerful, easy-to-use capability of integrating external programs, such as, Federal Logistics Data on Compact Disc (FEDLOG), WORDPERFECT, Automated Procurement and Accounting Data Entry (APADE), Hazardous Material Information System (HMIS), etc., and commands within the program. Integration is accomplished via a configurable, user-defined, drop-down USER menu and Hot Key system. The system also permits program expansion via integration of new program modules as they are developed. Users build their own menu, containing up to eight external programs, by simply selecting a menu item and entering a program name, start up command, and start up location (drive and directory). After a menu item is configured, the external program is executed by selecting the appropriate menu option, or pressing the associated hot key from any TSES screen. The user-defined menu is also accessible from anywhere in TSES via the Alt-F10 key. This point-and-shoot pop-up menu simplifies execution of external programs and seamlessly integrates TSES into the user's software suite.

Automatic Generation of Letters/Messages/Forms/Instructions: TSES reduces administrative workload by including a variety of correspondence, defined in the following paragraphs, which is automatically produced and can be configured (personalized) to each activity's needs. Correspondence can be printed or

directed to a file and transmitted via SALTS, modem, hardcopy, disc, in message or letter format.

Ships Hazardous Material Feedback Form (SFR). An SFR form is required for purchase of Non-Standard Hazardous Material (HM), not identified in the SHML as "authorized for shipboard use", and must be signed by the Commanding Officer (CO) of the ship. COMNAVSUPSYSCOM MSG 052345Z August 1991 requiring the CO approval, is referenced in a letter/message which is automatically generated for return to the requisitioner.

NAVSUP Form 87 Request for National Stock Number Assignment. Just as the SFR is generated for a ship requisition, this form is generated for purchase of Non-Standard, HM for shore requisitions. A letter/message, referencing NAVSUPINST 4410.50 B Elimination of Local Stock Numbers (LSN) of 03 March 1993 is on-line and automatically generated.

Non-Standard Database Update Letter. After input of a new item into the Local database, a letter/message which captures the data from the Screening process, is automatically generated to NSPCC for entry into the Non-Standard database and distribution to all users the following quarter.

HazMat (HM) Coordinator Authorization Letter. Input of a shore based requisition HM NSN which is not in the Local HazMat AUL will produce a letter/message which requires the signature of the HM coordinator prior to purchase.

Suspense Tickler File: Automatically keeps track of dates SFR and NAVSUP 87 Forms are due and indicates SFR DUE TODAY on the Screening Menu when applicable.

Built-in Tools: One of TSES menus, TOOLS, includes the previously mentioned letters/forms, as well as, other significant reference documents, identified below:

FED-STD-313C, Tables I and II (Appendix A), Material Safety Data, Transportation Data and Disposal Data for Hazardous Materials Furnished to Government Activities of 01 Mar 88. Accessed from the Screening or Tools Menu, Fed-Std-313C helps the screener identify those items which contain chemicals and require a Material Safety Data Sheet (MSDS).

Federal Supply Classification (FSC) Catalog, H2-1, Part 1, Groups and Classes of Sept 94. During the normal process of screening requisitions, the screener attempts to match an FSC to the non-standard item. The entire list of FSCs is available from the Screening or Tools Menu to eliminate the need for hard copy.

NAVSUPINST 4200.85A, Encl. 3 Shore and Fleet Small Purchase and Other Simplified Purchase Procedures of 17 Sep 91. Certain items, such as, filing equipment, require special attention. Specific FSCs have been assigned to these items and, if input, will automatically display a window explaining these requirements.

Procurement Related Information: As a requisition is processed,

it passes through the hands of technical and procurement personnel. If each screener is using TSES, they have access to the same information via a Technical Screen Summary. These summaries can be printed to a file, a printer or the screen. Each summary contains all the pertinent information input by the user and generated by the system research process. As can be viewed in the sample summary in Figure 2, TSES provides the user information necessary to process the requisition, such as, Material Safety Data Sheet (MSDS), Hazard Warning Label, and ODS requirements.

Requisition Number: V65789-3027-2632
NSN: 6850-00-003-1194
CAGE: 13664
P/N: H14
NAME: CLEANING AND LUBRIC
SMCC: W
ODS: CLASS I ODS (CFC 113/HCFC 22/CFC 12)

This item is an Ozone Depleting Substance (ODS) and is reclaimable, recyclable. Item must not be sent to DRMO or sold to non-DOD entity.

*** TECHNICAL CERTIFICATION IS REQUIRED PRIOR TO PURCHASE***

If standards, specifications or drawings in the contract specify the use of Class I Ozone Depleting Substances, Technical Certification signed by a senior acquisition official (Flag or SES only) is required prior to purchase and must be obtained by the Technical Services group.

UIC V20132, USS DIXON (AS 37),
is an AUTHORIZED user of the ODS Reserve.
This requisition CAN be filled from the ODS Reserve.

Item is in the SHML database and is AUTHORIZED for procurement. A Material Safety Data Sheet (MSDS) is required IAW FAR 52.223-3. The MSDS is required PRIOR to award.
A Hazard Warning Label is required IAW DFARS 252.223-7001 except for hazardous material subject to labelling requirements of one of the following:

(1) Federal Insecticide, Fungicide and Rodenticide Act;
(2) Federal Food, Drug and Cosmetics Act;
(3) Consumer Product Safety Act;
(4) Federal Hazardous Substances Act; or
(5) Federal Alcohol Administration Act.

A list of which hazardous material will be labelled IAW one of these Acts, and the applicable ACT, must be provided in lieu of the label.

MSDS and Hazard Warning Label Information must be forwarded to: Navy Environmental Health Center, Attn: Jim Crawl, 2510 Walmer Avenue Norfolk, VA 23512-2617, DSN: 564-4657.

FORWARD THIS ORDER TO THE HICS HAZMIN CENTER FOR PROCESSING

Technical Screen performed by Code 0541.

FIGURE 2 TSES TECHNICAL SCREEN SUMMARY

Reference Information: In the VIEW DATA DROP-DOWN MENU of the SCREENING MENU, TSES contains a wealth of reference information, in the form of lists: Acronyms, Dual Cognizance (COG) Codes, Special Material Identification Codes (SMIC), Type of Storage (TOS) Codes, Special Material Content Codes (SMCC), Shelf/Life (S/L) Codes, Shelf Life Action Codes (SLAC), Unit of Issue (UI) Codes, Unit Identification Codes (UICs), Hazardous Characteristics Codes (HCC), and Acquisition Advice Codes (AAC); as well as, ODS information.

Ozone Depleting Substances (ODS). The stratospheric ozone layer protects the earth from the penetration of harmful ultraviolet (UV-B) radiation. On the basis of scientific evidence, a national and international consensus exists that certain man-made halocarbons, including chlorofluorocarbons (CFCs), halons, carbon tetrachloride, and methyl chloroform, must be restricted.

In accordance with the Defense Authorization Act for Fiscal Year 1993, contracts that require the use of a Class I ODS cannot be awarded unless approved at a level no lower than a general or a flag officer or Senior Executive Service member.

Therefore, one of the most important features of TSES is the ODS information contained in three sections of the View Data Menu. The first (ODS) lists ODS names and their corresponding chemical names; the next section (ODS2) includes the NAVSEA/NAVSUP/NAVAIR/MARINE CORPS/MILITARY SEALIFT COMMAND AUTHORIZED USERS LIST FOR the ODS RESERVE and the respective memos authorizing these users, and the third section (OPAs) contains ODS Procurement Approvals. The complete NAVSUPSYSCOM msg 211841Z Dec 93 is also on-line, providing guidance for procurement and turn-in of Navy ODS HALON requirements. As stated in this reference, Fleet Industrial Supply Centers are NOT allowed to deviate from TSES' table of authorized users.

Batch File: The system screens the ASCII text file of stock-numbered requisitions and batch processes them through TSES. After processing, it separates for review the questionable requisitions, saves them in the requisition history file and creates and saves the summary of TSES actions on-line to view.

Historical Files: TSES maintains a file of requisitions processed and their summaries, which are automatically purged after six months.

Help: (F1 Key), TSES incorporates an extensive, context-sensitive Help system, plus an On-Line Tutorial and User's Manual.

Desk Top Manager: TSES has its own Calculator, Appointment Book, and Calendar.

Report Generator: As a management tool or as a means for each user to organize his data, a Report Generator is integrated into the TSES software package.

THE PLAYERS

NAVSUP is responsible for program oversight, implementation policy, guidance, and demonstration and training at

user activities; NSPCC, as NAVSUP's agent, provides programming, database administration and technical support in the form of data collection, demonstration and training at user activities, item verification and input, and integration and redistribution of database updates and program modifications.

Technical and procurement personnel at user activities are responsible for processing requisitions via TSES logic guide in compliance with CNO's HMC&M Program.

TSES - IN THE REALM OF CNOs HMC&M PROGRAM

As indicated previously in the ABSTRACT of this paper, HAZARDOUS MATERIAL MANAGEMENT/ENVIRONMENTAL ISSUES are identified in the Navy Supply Corps Newsletter of September/October 1993 as PREEMINENT ISSUES. TSES is at the forefront of these issues and is supporting policy through the implementation of OPNAVINST 4110.2, Hazardous Material Control and Management (HMC&M) of 01 May 90, which establishes guidance and requirements for the life-cycle control and total quality management (TQM) of hazardous material (HM) acquired and used by the Navy. As the TSES user base grows, the instructions/regulations necessary to comply with the HMC&M Program will permeate the Naval community in one self-contained software package. Some examples of how TSES implements OPNAVINST 4110.2 follow:

Paragraph 5(a) identifies "HMC&M as a life-cycle material and equipment requirement involving all elements of the Navy. The program requires HMC&M actions from concept formulation of a new or modified Navy system through research, development, acquisition, production, operation, and the final disposition phases. It involves line management at all levels and action of all concerned with each phase of acquisition of systems, components, material, or parts." *TSES simplifies this process by providing a PC-based software system designed to provide advisory support to technical and procurement personnel via a step-by-step logic guide. It further facilitates line management at all levels by providing a Technical Screen Summary, which is attached to each requisition as it flows through the system and reiterates all TSES actions completed and necessary for each acquisition.*

Paragraph 5(c) states that the "Occupational Safety and Health Act (OSHA) established requirements for training and informing workers of the hazards from the chemicals in their workplaces." *TSES incorporates the Ships Hazardous Material List (SHML) as an on-line database. The SHML not only identifies hazardous items which are authorized or prohibited onboard ship, but contains an Ozone Depleting Substance (ODS) indicator field identifying those items which contain ODS.*

Paragraph 6(b) asserts that "Navy activities shall comply with all Department of Defense (DOD) standards, directives, instructions, and regulations related to Hazardous Material (HM) and Hazardous Waste (HW)." *TSES incorporates FAR CLAUSE 52.223-3 Material Safety Data Sheet (MSDS), DFARS CLAUSE*

252.223-7001 Hazard Warning Label Exceptions, ODS requirements, including technical certification prior to purchase and states that ODS items are reclaimable/recyclable and must not be sent to the Defense Reutilization Management Office (DRMO) or sold to a NON-DOD entity. TSES also provides the SHML Feedback Report (SFR) and NAVSUP Form 87 requirements. All of these regulations and more are also identified in the Technical Screen Summary portion of TSES and must accompany the requisition to enlighten all acquisition process participants in the essential environmental requirements.

Paragraphs 6(c) (1)-(5) state that the "Navy shall control and reduce the amount of HM used and generated by upfront HM control in acquisition, procurement, supply, and utilization through the development of:

acceptable local mechanisms at shore activities to identify materials in the system that are hazardous....activity Authorized Use Lists (AUL)....a plan to review Navy specifications that direct use of HM or HW to determine if any changes are needed to further minimize the use of HM and the generation of HW....mechanisms for substituting less hazardous material for HM where technically feasible....an overall HMC&M program encompassing Hazardous Communication (HAZCOM) to promote and protect the health and safety of Navy workers, systems, system components, and the environment...."

TSES aids the requisition processor in the implementation of these policies and in control of HM throughout the acquisition process by providing:

the first standardized database for shore activities to identify hazardous materials in the system by assimilating the local AUL into the TSES format....the creation of activity AULs....review of Navy NSNs and specifications necessary to implement CNOs HMC&M Program through the continual update of six databases which reside in TSES, and the specifications which impact them....replacement NSNs in the SHML and local AUL where technically feasible and authorized plastic alternatives in the PRIME database....an overall HMC&M software program encompassing communication/ dissemination of hazardous regulations/requirements through automatic "pop-up" messages and a Technical Screen Summary....

Paragraph 8(b)(3) tasks the Chief of Naval Research (CNR) with the responsibility of issuing and ensuring compliance with codes, standards, and regulations regarding HMC&M....*TSES creates an accessible tool to disseminate this information to its users from ship to shore....as regulations change, TSES will continually be updated.*

Paragraph 8(c)(3) tasks the Commander, NAVSUP, to ensure the accurate assignment and use of NSNs for Navy HM....*TSES requires the completion of an SFR report for all non-standard hazardous items to enable the assignment of NSNs for afloat acquisitions and a NAVSUP Form 87, Request for NSN assignment,*

for non-standard hazardous ashore acquisitions.

Other instructions which impact TSES and its program are: DODINST 6050.5 DOD Hazard Communication Program of 29 Oct 90, DODDIR 4210.15 Hazardous Material Pollution Prevention of 27 July 89, OPNAVINST 5100.19C Navy Occupational Safety and Health Program Manual for Forces Afloat of 19 Jan 94, OPNAVINST 5100.23C Navy Occupational Safety and Health (NAVOSH) Program Manual of 13 Aug 93 and OPNAVINST 5090.1B Environmental and Natural Resources Program Manual of 01 Nov 94.

MAINTENANCE AND VERIFICATION

NSPCC is responsible for verification of all information in TSES and the maintenance of TSES data. As inputs are received from TSES users, they are researched through FEDLOG, Hazardous Material Information System (HMIS), Defense Logistics Services Center (DLSC), etc. prior to addition to the Non-Standard database. Quarterly, TSES lists and reference tools are updated as necessary; as well as, the Non-Standard, SHML, AMAL/ADAL and PRIME databases. The Local and Local AUL are updated by each user activity.

Each quarter, NSPCC distributes an updated software package to all users, including a quarterly newsletter, entitled TSES TIDBITS, which contains informative information pertinent to the TSES Program and its users.

SUMMARY

TSES is not just another stand alone application. It implements the CNOs HMC&M policies in an easy-to-use software system which can be accessed worldwide. It also creates a desktop manager allowing the user to access eight external programs, as well as providing the user a calculator, appointment calendar, report generator, etc. We strive to make TSES the most knowledgeable expert system available. Most of the information in TSES has been added from trips to user activities because we want TSES to work for the people who use it.

The TSES program has grown considerably since its inception. We have installed TSES at 75 shore-based activities, including all Fleet and Industrial Supply Centers (FISCs) and on 20 ships. Recently, the Aviation Supply Office (ASO) evaluated and plans to implement TSES in conjunction with their part number database/requisition processing system. As stated previously, TSES has sufficient procurement and technical data fields to accommodate the ICP database and to be the vehicle that the fleet and shore activities can use to interactively obtain and provide technical data during the technical screening process. We are providing the POLICY, TOOLS, and TRAINING which position TSES to be the provider of choice for the dissemination of environmental information to fleet units and shore stations.

ACKNOWLEDGEMENTS

The authors thank Mr. Frank Sechrist, Supervisor of the Environmental Control and Packaging Programs Division of NSPCC for his insight and suggestions provided during the preparation of this paper.

REFERENCES

1. Rear Admiral R. M. Moore, SC, USN, "Charting Our Future Course: Preeminent Issues", **The Navy Supply Corps Newsletter,** September/October, 1993.

2. **Hazardous Material Control and Management (HMC&M)**, (OPNAVINST 4110.2), 01 May 1990.

THE ACQUISITION DESKBOOK

"A NEW WAY OF DOING BUSINESS"

Frances M. Valore
Defense Systems Management College

ABSTRACT

The Acquisition Deskbook concept embraces the notion that it is good business practice to let the market processes create and nurture the "Best of Breed."

The Under Secretary of Defense (A&T) chartered the Automated Acquisition Information Process Action Team (AAI PAT) to define the vision and build the roadmap for implementation of a process to disseminate information throughout DoD. The vision and the roadmap begins with the **Acquisition Deskbook**, the Deputy Under Secretary of Defense (AR) initiative, and expand this concept, to institutionalize a "new way of doing business within DoD."

The Acquisition Deskbook

The Deskbook will be an enabling technology to promote new ways of thinking, and new ways to conduct business. The Deskbook concept changes not only the means by which acquisition professionals are provided reference information to make informed decisions, but will change the way we view business decision options. The Deskbook nurtures these changes by providing acquisition professionals with current and complete information at their fingertips, presented in a configuration corresponding to thinking processes.

Three integral components make up the Deskbook: A **Reference Set,** a **Tool Catalog**, and an electronic **Acquisition Management Forum (AM Forum).** A Joint Functional Team (JFT), consisting of representatives from each Component Acquisition Executive (CAE), the Office of the Secretary of Defense (OSD) and the Defense Systems Management College (DSMC) will identify the data to be included in the **Reference Set,** a structured collection of categorized and certified acquisition information vital to acquisition management. The **Tool Catalog** is a database of software acquisition tools, currently available or under development, describing the functional capability, systems compatibility, and a point of contact for each individual tool. The **AM Forum** is an unstructured and informal electronic information exchange to facilitate the rapid flow of good ideas and information throughout the acquisition community.

Acquisition professionals will have an electronic "one stop shopping" center that provides key reference information. To make the service widely available, the Deskbook will be an integrated software application that can be used as a stand-alone installation, on a network, or accessed remotely via the Internet, World-Wide-Web, or dial-up modem.

BACKGROUND

"With successful implementation, acquisition reform should change the way we conduct business within the DoD." - Honorable Paul J. Kaminski, The Under Secretary of Defense (A&T).

In order to implement this change in the way we do business, Dr Kaminski chartered the Automated Acquisition Information Process Action Team (AAI PAT) to **"...Define a vision and build a roadmap to institutionalize an automated acquisition information process to provide current and comprehensive information and tools for the Office of the Secretary of Defense (OSD), Services and Program Managers to effectively and efficiently buy weapon systems."**

To realize this vision, the PAT developed four goals to describe the desired end-state acquisition information environment:

Goal 1: An automated acquisition information process will exist that provides timely and effective information sharing.

Goal 2: A streamlined automated tracking, monitoring and reporting information process, integrated with program management planning and execution tools, will be in place and operating.

Goal 3: A "library" of automated acquisition tools and information will exist and be accessible to all.

Goal 4: Training and support on AAI systems will be fully institutionalized.

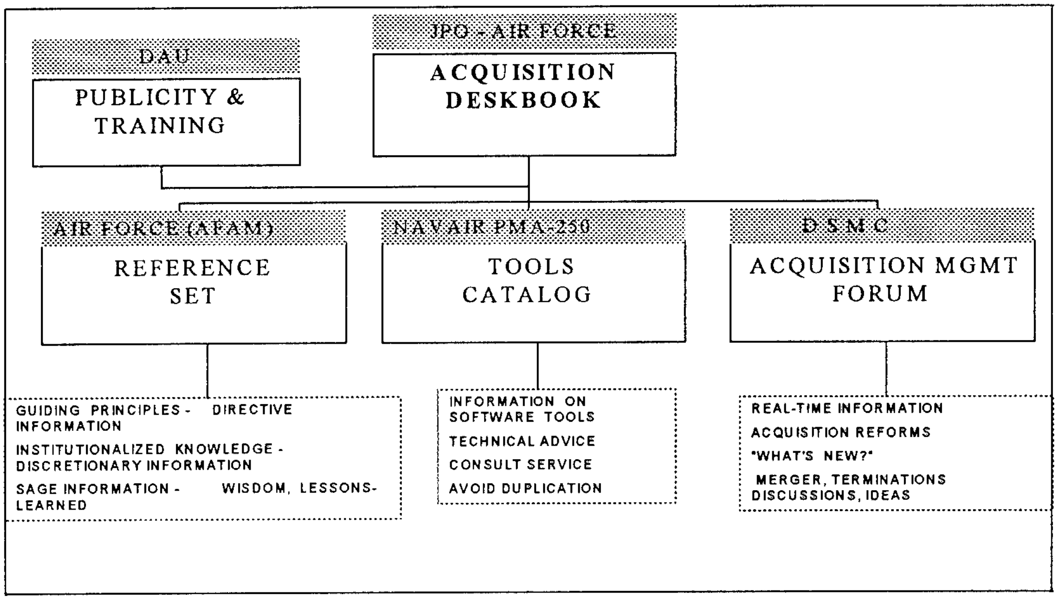
The PAT plan of action to define the vision and develop the roadmap coalesced into two systems or processes: the creation of an Acquisition Deskbook system, and the development of an Automated Program Status Reporting (APSR) system. They are described below.

The Acquisition Deskbook

The Deskbook will be an integrated, electronic desktop system for the exchange of information to support the acquisition community. Timely access to complete, relevant information, structured to advance managerial discretion, will promote a new way of doing business.

Three separate, integrated components address unique elements of acquisition information. The **Reference Set** is a structured information set - collected, identified, categorized, and certified by a Joint Functional Team (JFT). This Team consists of representatives from each Component Acquisition Executive (CAE), the Office of the Secretary of Defense (OSD) and the Defense Systems Management College (DSMC). The **Tool Catalog** will be a database of software acquisition tools currently available or under development, and will describe the functional capability, systems compatibility, and a point of contact for each individual tool. The **Aquisition Management Forum** will be an unstructured, informal, real-time information exchange to facilitate idea generation and information exchange throughout the acquisition community.

ACQUISITION DESKBOOK



The Deskbook initial phase will be operational in September 1995, given direction and timely, sufficient funding.

The Deskbook will be an electronic "one stop shopping" center that provides the acquisition community with key reference information. It will be an integrated software application that can be used as a stand-alone installation, on a network, or accessed remotely via the Internet or dial-up modem.

The Automated Program Status Reporting System (APSR)

Goal #2 in Dr Kaminski's vision was addressed external to the initial Deskbook system; however, the plan has the reporting process, over time, integrated with program management planning and execution tools. The overall acquisition information process takes advantage of emerging technology, to further an evolving acquisition culture of good business practices.

The APSR system originates with the development of a data dictionary that defines selected elements of program information needed for program oversight. This data dictionary will be the foundation for a database developed to support an automated, non-intrusive monitoring, tracking, and reporting process. This system will replace other forms of oversight reporting, and provide timely and accurate information, while reducing costs associated with duplicated program management efforts.

The Army will establish and manage the development of the APSR system, and will coordinate appropriate APSR actions with the System Acquisition Management Corporate Information Management (SAM-CIM) efforts to achieve consistency and efficiencies.

The Director, DUSD(A&T) API, will

chair the JFT governing the Deskbook and the APSR system efforts, and the SAM-CIM efforts.

Numerous official and unofficial studies and reports have documented the need for acquisition managers to have valid, accurate, and timely information to avoid "surprises," often in the form of unexpected project cost increases and schedule slippages. Historically, the bureaucratic response has been to develop a new "rule" to prevent that specific re-occurrence. Unfortunately, these rules are perceived as inviolate and inflexible, and as such, become a substitute for thoughtful judgment and decisive action.

Managerial expertise, and discretional judgment has always been, and continues to be, critical to successful results. In the politically charged defense arena this is especially true. No amount of organized, systematic 'checklists' can substitute for the valuable art of decision-making based on cumulative management expertise, thoughtful analysis of a situation, and finally, the courage to make a judgment call in a risk-filled environment.

The current environment, within which REGO (REinventing GOvernment) is encouraged at the highest levels, brings opportunities to re-insert a heightened awareness of the managerial discretion available to government careerists. Information flow processes should be structured in ways that promote this awareness to enable informed decisions by acquisition professionals. The organization of Deskbook information enables users to more easily distinguish between that which is Public Law or Directive and which is Discretionary.

Technology exists today to place current policy, guidance and automated tools for program management at the fingertips of every acquisition professional. More timely and accurate program information can be made available to decision makers and their staffs.

The Reinventing Government philosophy, coupled with available and emerging technology, offers chances to make real and enduring differences. The political and economic climate encourages, if not forces, creative solutions while the Department braves significant redefinitions of its roles.

The Deskbook concept uses available technology to encourage new ways of managing acquisition business. It offers opportunities to reduce workload on program managers, to eliminate the requirement for compiling periodic reports, to greatly reduce the cost of publishing acquisition directives, and to facilitate the flow of useful information throughout the acquisition workforce.

CHANGING A CULTURE

... Envision a near future that endorses application of emerging technology, creative thinking, and rewards proactive decision making ...

Problem 1: *Dissemination of Acquisition policy and approved practices can take weeks or even months to reach the members of the acquisition workforce. Also, no fast path exists to share "good ideas" across the Components.*

Goal 1: An automated acquisition information process will exist that provides timely and effective sharing of information.

Problem 2: *Acquisition managers spend significant time and resources to generate oversight reports. Responsible decision makers do not always have access to the most current information.*

Goal 2: A streamlined automated tracking, monitoring and reporting information process, which integrates with program management planning and execution tools, will be in place and operating.

Problem 3: *There is no centralized list of acquisition management tools. No procedure exists by which acquisition managers can investigate the existence of a software tool to meet their needs before developing their own. As a result, acquisition managers devote a significant amount of time and money each year developing automated tools that already exist.*

Goal 3: A "library" (e.g., inventory, index, catalog) of automated acquisition tools and information will exist and be accessible to all.

Problem 4: *Acquisition workforce training does not adequately use the many tools available in the normal curriculum. Existing tools are not widely publicized to the acquisition workforce.*

Goal 4: Training and support on AAI systems will be fully institutionalized.

The Deskbook system addresses the problems and goals #1, 3, & 4. The APSR System addresses Goal #2.

The Deskbook system will have a user-friendly graphical display with an intuitive user interface to minimize training requirements. A flexible user interface, navigational mechanisms and search functions will satisfy new users as well as experts. Information will be presented to the user through standard graphical user interfaces (i.e., Windows and Macintosh). The system is designed to be Internet-compatible and installable on either a Local Area Network or a standalone computer.

The library of information will be developed logically through an iterative approach and will be implemented using a continuously evolving database. The Deskbook will link to existing databases and services, where appropriate, to avoid costly duplication.

The Reference Set volume of the Acquisition Deskbook provides the opportunity to support a basic change in the acquisition culture. Information in the Reference Set is organized into categories:

Guiding Principles	Directive Information
Institutionalized Knowledge	Discretionary Information
Sage Information	Expert wisdom, Lessons Learned

By organizing the Reference Set information into categories, the Deskbook sends a clear message that the use of discretion and judgment are mainstream elements of our business process. The Reference Set information categories require multiple levels of certification. Guiding principles must be approved by an appropriate authority. Institutionalized knowledge will be approved by the process owners, and Sage Information will come from anyone with applicable experience and a willingness to share ideas.

The information is further divided to focus on specific interests and audiences, and to differentiate between DoD and Component applications. Users will have a variety of ways to access the information, and must re-orient their search for the right "rule," and become familiar with new information categories.

Guiding Principles. This information describes the products and processes the acquisition community **must** produce and follow. This area includes mandatory provisions, directives policy, operating procedures and regulations. Information in this category must be approved by the appropriate Acquisition Executive (AE) or designee. Example: DoD 5000 Series.

Institutionalized Knowledge. This information describes the products and processes the acquisition community **may** produce and follow. This area includes alternative approaches that have been tried and approved for use, either generally or for specific applications. Information in this category must be approved by the process owner designated by the appropriate AE. Example: Service-specific requirements.

Sage Information. This information describes learned advice from functional experts, lessons learned from past experiences, status of "pilot" programs, and general information that is neither directive nor discretionary. This information must be approved by officials who have been delegated this authority by an AE. Example: National Performance Review Pilot Programs.

Information in the Reference Set is further sub-divided into Classes:

- DoD-Wide
- Service/Agency-Wide
- Buying-Activity Specific

The Defense Acquisition Executive (DAE) controls the approval process for the DoD-Wide class of information.

The Service Acquisition Executive (SAE) or Agency senior acquisition official controls the approval process for The Service/Agency-Wide class of information.

The Buying-Activity senior acquisition official controls the approval process for The Buying-Activity Specific class of information.

The USD (A&T) will establish a process to certify and categorize the information to be included in the Deskbook in the "DoD-Wide" class of information. This process will be developed in conjunction with the current rewrite of the DoD 5000 principle acquisition documents.

Each Service and Agency will establish a process to categorize and certify the information to be included in the Deskbook in the specific "Service/Agency-Wide" class of information, e.g., Air Force, Navy, Army, DLA and SOCOM.

Each Buying Activity will establish a process to categorize and certify the information to be included in the Deskbook in the specific "Buying Activity" class of information, e.g., ESC, NAVAIR and TACOM.

Envision the Deskbook as the living tree trunk, that encompasses the combined knowledge of the acquisition community. The Services and Agencies feed practical experience information up through the roots, and OSD and the Administration feed guidance and fundamental principles down through the branches. In the center, the information comes together in the Reference Set.

The appropriate level of certification is important to ensure the process is streamlined and disseminated rapidly throughout DoD. Guiding Principles information should change infrequently. This information has the greatest effect on the practice of acquisition, and the certification process should have high level review and coordination. The relevant AE is the appropriate certification official.

The Institutional Knowledge category provides approved alternative practices. Certification should be delegated to appropriate process owners within the Component or Department.

The Sage Information category collects and promulgates promising ideas, lessons learned and advice throughout the Department. The certification process should be delegated to the lowest possible level. A lengthy and top-heavy review process for the Sage Information category would be counter-productive.

Each Component currently has personnel assigned to develop and coordinate policy information; these individuals' efforts should be realigned to be consistent with the Deskbook concept and the revised information categories. The re-write of the DoD 5000 series documents will formalize these information categories.

A Joint Program Office (JPO) will manage the overall Deskbook System. The existing Air Force Acquisition Model (AFAM) program office will form the initial cadre for the Deskbook effort to take advantage of their experience in building an acquisition reference system for the Air Force, and their existing infrastructure. The program manager will rotate through the Services every 3 years in the following sequence: Air Force, Army, Navy/Marine Corps. The AFAM organization will become the Deskbook Program Office.

In addition to the overall Deskbook management functions, the Air Force AFAM Program Manager will be responsible for the establishment and management the Reference Set component of the Deskbook.

The Joint Functional Team (JFT)

These information collection and certification processes offer opportunities for a “Joint” look across all Services and Agencies, to review other components’ Guiding Principles and Institutional Knowledge information for potential application across all the Components. The Reference Set Information Coordinators from each of the Component review boards will form a JFT. This Team will coordinate potential joint guiding principles and institutional knowledge and present their recommendation to a Joint Service Review Board for endorsement across the Components.

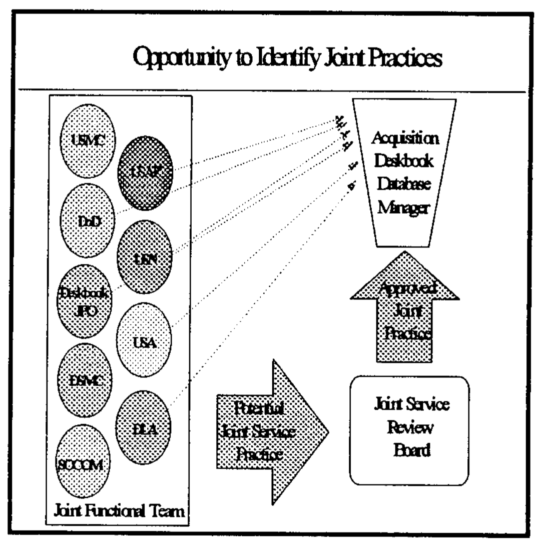
The JFT will work with the Deskbook Joint Program Office (JPO) to establish the “views” into the information. The Deskbook will contain a tremendous quantity of data; therefore, the available methods for the acquisition workforce to view that information are critical to the Deskbook becoming the reference source the workforce chooses to use.

The JFT will approve requirements and perform oversight functions for the DoD Acquisition Deskbook. The JFT management structure ensures a DoD-wide vision for automated acquisition information, while sufficiently recognizing the importance of maintaining Service/Agency-unique requirements. Each AE will be responsible for establishing internal processes to identify and approve information for incorporation into the Deskbook.

To ensure the Deskbook maintains a DoD perspective, the JFT will be chartered to recommend DAE approval of alternative practices and "good ideas" that cross Component lines. They will be explicitly tasked to seek out those practices and policies introduced at the Component level that may be appropriate for Joint implementation. Members will represent their respective Components on the JFT, and serve as the Component advocate for the Deskbook..

The JFT will consist of senior-level representatives (O-6 or GM-15) assigned from each of the following organizations:

· Director, API, Chairperson
· Deputy USD(Acquisition Reform)
· Army
· Navy
· Air Force
· Marine Corps
· Defense Logistics Agency
· Special Operations Command
·Deskbook P.M. (Technical Consultant)
· Defense Systems Management College, Executive Secretariat & Host



The Tool Catalog: The purpose of the Tool Catalog is to provide a central

library or referral for acquisition managers. Today's environment isolates the multiple markets available for determining the availability of software tools, and leads to widespread proliferation and duplication. A need for a tool is identified by a single program office or a small group of offices. They then develop the needed tool, or an enterprising commercial company sells them an existing tool. This process is repeated in isolation throughout the acquisition community. Individual acquisition managers do not have the information available to determine whether a tool already exists elsewhere. The Tool Catalog will reduce duplicate development and provide the following information:

· Tool functional classification
· Functional Description
· Assessment of Capability
· Software and Hardware Compatibility
· Implementation/Support Cost
· Identify Current Users
· Tool Owner and Acquisition Source
· Contract Vehicles, if Any
· Date Of Last Upgrade

Acquisition tools will be classified functionally in the following categories:

· Industrial/Manufacturing/Quality Assurance
· Reference
· Program Management
· Financial Management
· Contract Management
· Engineering
· Configuration Control
· Test and Evaluation
· Logistics
· Foreign Military Sales
· Safety
· Security
· Environmental
· Installation Management
· Construction Management
· Human Systems Integration
· Others, When Identified

In addition to the cataloging function, a consulting service will be provided to support the Tool Catalog. As users consult the Tool Catalog service, the Deskbook will collect trend information on the automated tool needs of acquisition managers. This information can then be analyzed and provided to the Joint Functional Team (JFT). The Navair PMA-250 will manage the Tool Catalog.

The Acquisition Management Forum: The AM Forum component of the Deskbook will be an electronic information exchange to facilitate the flow of unstructured information within the acquisition community. The Forum offers timely, informal exchanges of information, advice, ideas and consultation and could enable teaming opportunities with others having similar projects, questions, concerns, or initiatives. Examples of items that may be included in the Forum are:

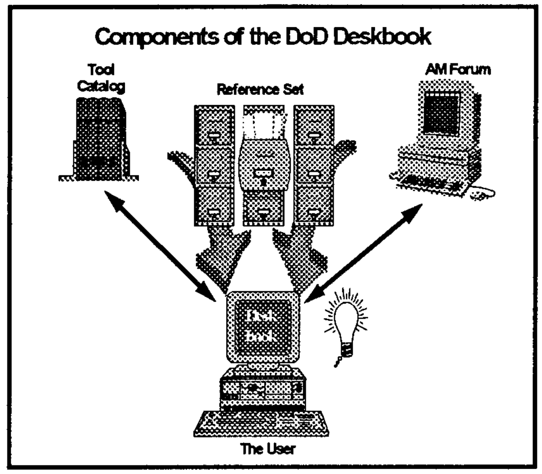
· Pilot Programs Status
· Acquisition Reform Initiatives
· New Ideas, Alternative Practices
· Distance Learning Applications
· Open Discussion and Feedback
· Notices - Course Offerings, Conferences, Seminars
· New or Emerging Policy

The AM Forum will communicate survey findings, concerns and current

issues, coordinate expert functional responses to queries, and transmit real-time status of pending legislation, PPBS updates (Committee Mark-ups, etc.) and other items of interest indicated by users/customers. An AM Forum central focal point will facilitate the exchange of top-down, bottom-up and horizontal information that is consistent, valid, accurate and timely. The Forum will have external interface and coordination (legislation, executive actions, hot news) and internal interface and coordination (OSD, Services and Agencies).

The AM Forum organizational functions include information collecting, screening, directing and disseminating, but does not include certification or approval functions. The key to holding a forum that people want to use has less to do with fancy graphics or quick connections, but with the people and the information they find there. The intent is not to see warm and fuzzy, sanitized, approved information, but instead to encourage open discourse, a gloves-off exchange of ideas, and rapid communication among multiple DoD community users. The AM Forum will be available via Internet, telefax and telephone message 24 hours a day, and staffed during normal duty hours.

DSMC will establish and manage the AM Forum and use the Forum to support DAU in the planning and distribution of publicity and training to support the Deskbook system.



Training/Education:

The Defense Acquisition University (DAU) will coordinate the training and education requirements to ensure the Deskbook concept is institutionalized. Target date for full integration of the Deskbook into the applicable DAU consortium curriculum is Mar 96.

The DAU, upon determination of need for new courses or additions to existing courses, will coordinate the development of all training and education functions for the Deskbook, targeting applicable courses at all levels.

The core competencies for Deskbook instruction should include an appropriate emphasis on the underlying philosophy of the Deskbook, as an enabling technology to disseminate information on a "new way of doing business." The Defense Acquisition Corps Functional Boards will determine the need to develop new competencies, or revise their respective functional competencies accordingly, and task the DAU to develop or revise applicable course curricula.

TO NEW WAYS OF THINKING

The Deskbook product and associated services has been a mission motivated by an important vision. The AAI PAT members were driven to achieve our goals, because it mattered to each of us, albeit in a variety of ways.

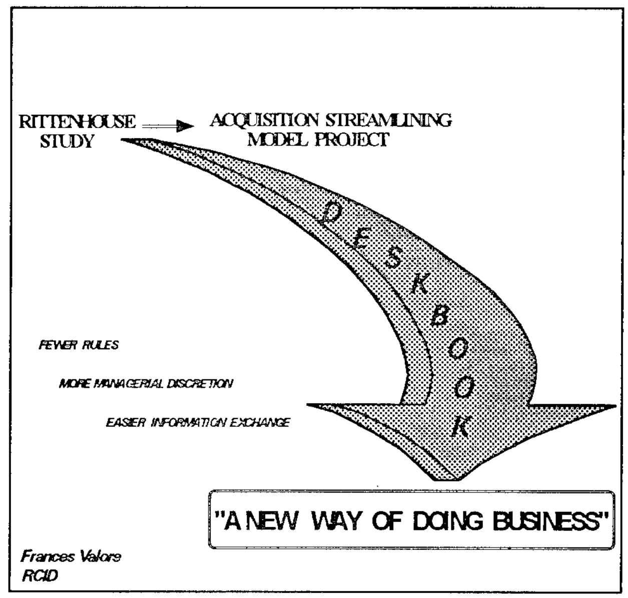
Don't consider the job finished now that the PAT has completed its initial mission - to define a vision and develop a roadmap. Each of us on the "global team" has a vested interest in some part or all these goals and objectives. The PAT achieved hard-won alliances on issues that mattered most, and a workable consensus on others.

Along the way, we bought into the process that brought about the commitment. We will take with us this process of sharing that creates enthusiasm to enhance our futures. We found ways to successfully bridge differences and truly bring the best of each into a product. The product is a "beginning" we will all expand to make a difference in our fields.

Although new ideas are often resisted, passions for specific ideas, principles, people or things reside within us all. In the quest to define the vision, goals and objectives for DoD's automated acquisition information future, each member of the team worked to construct a process within which individual passions could thrive. The final vision will indeed incorporate these ideas, and is designed to seek more shake-up ideas.

We are destined to find new ways to conduct our business defense-wide and globally. The team and its dynamics are representative of DoD's diversity of backgrounds and interests. It proved to be an encouraging testing ground for paradigm change. Laboriously, even sometimes painfully, we achieved milestones - not closure - on the first phase of the Vision Roadmap.

New ways of thinking won't show up in the mirror one morning. True measures of success are difficult to define, and to achieve, which is why they are so valued.



The Deskbook itself is an idea. How good the idea is depends upon how we use it. The concept is much more than is immediately evident. It is an excellent beginning to push us to expand our most rigid boundaries.

END NOTES:

1986 A.D. Little Industry Survey Report

1990 Defense Science Board Acquisition Streamlining Task Force Interim Reports

May 1991 DoD/Industry Survey Report

April 1994 DoD Acquisition Streamlining Model DSMC Research Project

Dec 1994 Oversight and Reporting PAT Report

April 1995 Automated Acquisition Information PAT Report

AIR FORCE ACQUISITION MODEL (AFAM) - THE LIVING DATA BASE

Daniel M. Whye, Captain, USAF

ABSTRACT

Nearly everyone is apprehensive when doing something new. In the complex acquisition process, "first exposures" are particularly challenging. Fortunately, Air Force Acquisition Command (AFMC) has fielded an acquisition tool to meet this challenge. It's called the Air Force Acquisition Model (AFAM). The AFAM is a personal computer database that describes AFMC's acquisition "tasks" across all six acquisition phases. It describes tasks, references, wisdom in the form of best practices, lessons learned, and expert advice; tools to help complete the task, and timeline information for more than 5,000 acquisition tasks. All of this plus a supplemental, hyper-text search and retrieval library know as the Air Force Acquisition Model Supplement (AFAMSUP) containing 170 key acquisition directives and guides. To ensure all of the information in each phase is comprehensive and complete, the database is updated and expanded with each release. The model version 2.1 released in March 1995 is the seventh release from the Acquisition Model Program Office located at Aeronautical System Center (ASC), Wright-Patterson Air Force Base (AFB), Ohio.

INTRODUCTION

Just imagine a tool at your fingertips that is a repository for the Air Force acquisition and product management process. Like the Yellow Pages, a tool you can let your fingers do the walking to aid you in accomplishing a specific task or tasks during a major acquisition milestone phase. A tool that helps you to determine where to begin a project and to avoid reinventing the wheel. This mega-tool has been years in the making. All you need is a 386 computer with Windows, and an inquisitive mind. This tool is the AFAM, a computer data base that describes the processes of Air Force acquisition and product management. It is an automated encyclopedia depicting and outlining all six phases of the acquisition process. The model is designed to assist research & development, acquisition, and support personnel in performing tasks for major weapon system programs and non-major acquisitions. Although acquisition is in its name, the model takes a "cradle to grave" approach in the life cycle of the system.

General Yates -- The Lightning Bolt

The model is the brainchild of General Ronald W. Yates, commander of Air Force Materiel Command (AFMC). He recognized that in an era of downsizing, reduced budgets, and reengineering our processes, the Air Force acquisition corps couldn't afford to keep reinventing the wheel. General Yates, then commander of Air Force Systems Command (AFSC), wanted an automated tool to define the acquisition and sustainment process as well as a method to share best practices and lessons learned to assist the acquisition and logistic communities. He took the initiative to put together a program that captured our

best practices. During the transition to AFMC, he and General Charles C. McDonald, then commander of Air Force Logistics Command (AFLC), established an integrated program office in the Center for Supportability and Technology Insertion which is part of ASC. The program office was chartered to develop a model to capture the Air Force acquisition system.

General Yates' emphasis on the need for AFAM was twofold. He said, "We can't teach and we can't learn. When we have to accomplish a task that we've never done before, we don't have a well-equipped tool box to select the tool or blueprint we need to accomplish the task. Experience has shown we look for someone who's done the task before or we look for a recent example to use."

No matter what the scenario is we may spend a lot of time tracking down the so called "expert" or we run the risk of using a "bad" example. AFAM captures successful experiences and documents and makes them available to everyone. General Yates said, "During this period of reductions, we are losing the experienced people who have the corporate knowledge." "Therefore, tools like the AFAM will help us produce quality products the first time." It will ease the learning curve process and provide the "road map" to accomplish the job. Finally, he stated, "It will allow us to quickly convey changes to the field -- with a sense of urgency."

AFAM Genesis

Development of AFAM began in November 1991 with a prototype developed for demonstration to the joint staff of the Air Force Logistic and Systems Commands in January 1992. The AFAM Program received 100 percent endorsement and program go-ahead. People within the command were tasked to develop computer displays, data management programs, and task field organizations to proof the embedded processes and contribute their wisdom and expertise. Thus the Air Force Acquisition Model was born.

Colonel Mike Ferrell, director of Acquisition Model Program Office, said, "Our goals were to create a just-in-time training tool that would teach, capture best practices, and give program directors the information they need to plan, manage, and execute their programs." We started with approximately 30 hand-picked people who represented the major functional areas, such as contracting, financial management, and the like, and we developed a preliminary model. "Then we created a customer requirements review board of people from each center within AFMC and asked them to tell us what they liked about our preliminary model, and what they wanted and needed. They were the ones who shaped the first model release."

Eight months later, what emerged was a personal computer data base that summarized the latest set of Air Force rules, regulations and policies governing the acquisition and sustainment process. The model was on its way to become the "how-to" recipe book using the best ideas and guidance available from DOD talent and experience. Subsequent releases occur every six months to ensure the model reflects current business practices and the most recent corporate knowledge. Originally targeted toward the inexperienced, AFAM has expanded its audience to include all acquisition personnel.

AFAM Matures

AFAM has been extremely successful because it is very easy to use and has high quality information. Anyone who can point and click a mouse or use a keyboard can quickly access valuable acquisition information. The information in the model is reliable since it's been provided by AFMC experts and then validated by AFMC functional directors. Since it has been fielded, users claim it is a significant time-saver and reference tool. The goal is to expand the AFAM capability from describing what is required to accomplish basic tasks in each phase of the acquisition life cycle to actually assisting the user in accomplishing tasks.

Infrastructure

Since its inception and with each AFAM version release, the model continues to add more enhancements and data to the growing customer base living up to its name as a "living data base." AFAM now requires as a minimum an IBM compatible 386 computer with a 4-megabyte (MB) RAM; 60 MBs of hard disk space; a VGA monitor and a mouse that is preferred over the use of a keyboard. The minimum software requirements are Microsoft Windows 3.1 or Microsoft Windows NT. Based on these hardware requirements, the increasingly popular use of a local area network (LAN) provides easy access to AFAM. The AFAM Program Office distributes the model to users on File Transfer Protocol (FTP), CD-ROM, or 3.5" high density disks. The availability of AFAM is limited only to the users hardware capabilities.

AFAM Features

The AFAM identifies and organizes more than 5,000 tasks and subtasks covering functional processes as task breakdown structures (TBS) within the six acquisition phases; pre-concept exploration, concept & exploration; demonstration & validation, engineering & manufacturing development; production & deployment, and operations & support. It describes each task associated with a particular acquisition process in common layman terms. Details for each task include information such as required inputs and outputs, approximate timelines, and resources required to complete the task.

"We couldn't assume anything," said Col. Ferrell. "We took the approach that if a certain task consistently takes 13 steps, our people should know what they are, how much time each one takes, the resources needed to complete them, and the pitfalls to avoid. That doesn't mean that every person will get from point A to point B using the same route, but at least they'll all have the same road map."

To illustrate, a user is assigned a specific task to accomplish. They may ask themselves "Where do I start?" The model's software displays five methods to look up tasks within six acquisition phases. They are: Keyword Search, Document List, Graphical, TBS Hierarchy, and TBS List.

- Keyword Search - is the capability to look up a familiar word or phrase that is common to a specific functional area, for example, "acquisition plan."
- Document List - are documents identified as required documents used by the functional areas to accomplish a

task, for example, "acquisition decision memorandum."

- Graphical - displays the network as a flowchart, illustrating the relationships between the tasks.
- TBS Hierarchy and TBS List - displays tasks down to six levels within a process, for example, "5.A.1 - Manage Modifications" to "5.A.1.2.3.5 - Maintain Funds Data in Mod Mgt Sys (MMS)."

The model's software aligns the tasks in a predecessor (before) and successor (after) network. This network allows the user to walk through the acquisition and support processes. Figure 1 displays the Task Relationships screen which is the entrance window for accessing task information or to examine predecessor and successor tasks. This screen is the master key to open the door to the details of a task. Simple clicking the Description, References, Wisdom, Tools, or Timeline buttons displays key information about the task. The Local Info button is reserved for users to store information related to their system.

Each of the 5,000 tasks provides key acquisition and sustainment information in the following areas in the form of a "detail button" found on the Task Relationship screen shown in Figure 1:

- Task Descriptions -- each task is described briefly in common terms in

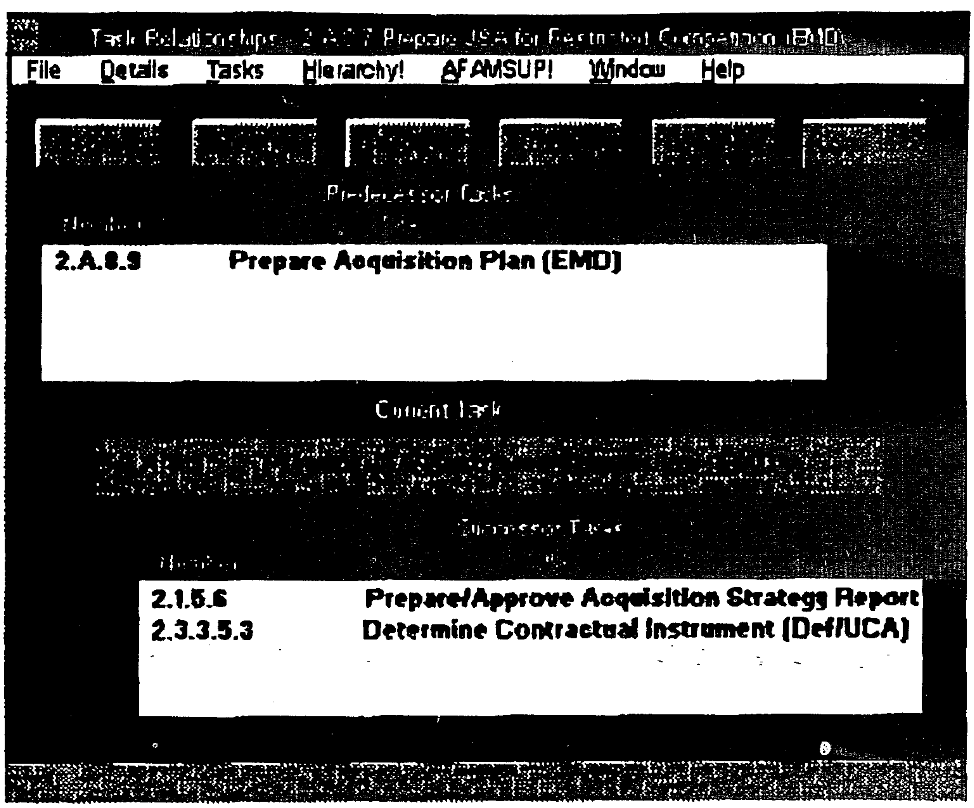


Figure 1. Task Relationship Screen

one or two paragraphs. Some are two or three pages. Task inputs and output are included here. Inputs are those things (documents, information) from other processes that are required to complete the task at hand. Outputs are those products of the subject task. Office symbols and phone numbers of organizational "experts" are also listed in the description files.

- References -- brief synopses of each directive, regulation, instruction, and policy letter that applies to that task. When possible, each referenced item provides the user the appropriate paragraph number. Many believe this is one of the best features of the model. Also, documents in the AFAMSUP have a direct link in this area to the supplement. This link will take you directly into the exact reference in the document. It assists and guides the user to the right requirement.
- Wisdom -- the heart of AFAM that captures the experiences of AFMC's most seasoned experts. It consists of best practices, lessons learned, and expert wisdom. Recommendations, practical advice, and a compilation of actions "to take or not to take" are also available.
- Tools -- composed of templates/samples, courses, software tools and miscellaneous tools that help the user complete the task. This display provides ready access to electronic templates/samples to prepare or update a document. It provides a synopsis of available training for the task such as courses offered at the Air Force Institute of Technology, Air and Education Training Command, or various other training facilities. Software tools information is included concerning the purpose and capabilities of the tool that an individual would use during the task. Finally, the miscellaneous tool data file contains information which does not readily fall into the other three "tools" categories.
- Timelines -- a "nominal" indication of the time and resources required to complete the task. This information can assist the program manager in establishing a schedule.
- Local Information -- as previously mentioned is an area reserved for users to store their own information related to each task.

Finally, packaged with AFAM is AFAMSUP, a fast text search/retrieval tool, with key reference documents such as DoD directives, Air Staff and MAJCOM policy letters, regulations, instructions, military standards, pamphlets, guides and handbooks. Although AFAMSUP may not have all of the "essential" documents needed for a particular task or process, it does provide a repository of documentation in one location. Users have found this key reference search and retrieval capability an extremely popular aspect of AFAM. The latest release, AFAMSUP Version 2.1 contains 170 reference documents. It is updated semi-annually and with each release additional documents are added. Like AFAM, it is distributed in a Windows environment, giving the user more capabilities and familiarity. AFAMSUP makes research easier and saves time -- a scarce resource these days.

Continuous Improvement

Future enhancements will include the link capability to use software like "PerFormPro" to create documents for

specific tasks. This will make the model a "doing" tool rather than a reference tool only. Another development will make AFAM available "on-line" to the user. AFAM as a multi-platform application for use on MacIntosh computers. Another major improvement under development is the full-text search capability of AFAM data. The user will have the ability to search the entire database for a specific task or subject.

Customer requirements review boards contribute significantly to the continued enhancement of the AFAM processes and data. The intent is to continue to capture the customer's or the user's desires when it comes to a specific process and the associated tasks within each process to get the work done. The database continues to expand to include all tasks associated with each phase. For example, the increased emphasis to develop the operations & support phase as it is in the other phases. Ultimately, the model will truly reflect the product management and sustainment business.

CONCLUSION

Contrary to popular belief within the acquisition corps, the AFAM is not just a tool to teach new people the acquisition business, though it is invaluable in that role. It's just as important as a medium for communicating accurate knowledge, wisdom, tools, policy, processes, and procedures to all users. As an AFAM HQ AFMC Financial Management (FM) representative, it is my task to ensure that the model's database reflects current FM processes and policies that affect the FM community. This responsibility holds true for all functional representatives.

As the workforce downsizes and we painstakingly reengineer our processes, the use of the AFAM will create a significantly more efficient and smarter acquisition corps. The process of continual improvement in our constantly changing acquisition environment makes AFAM the ideal tool. The AFAM baseline is now in review by the DoD Acquisition Reform team as a candidate prototype for the DoD acquisition system.

(Please note that the views, opinions, and/or conclusions in this paper are those of the author and should not be construed as Department of Defense of other government agency official position.)

SYSTEM PERFORMANCE AND TEST/EVALUATION

REQUIREMENTS VERIFICATION IN A MIL-SPEC FREE ENVIRONMENT

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ABSTRACT

A systematic approach for tracking a Requirement/Verification match-up for all contract specification requirements on a program is presented. The process has successfully been used on hardware systems delivered to the Air Force.

The process is described from the early stages of a program to completion and sign-off of requirements, with its relationship to all verification/test documentation, and resulting test reports.

The process is shown to strongly adhere to the principles of design to test, and provides the thread of consistency throughout the project. Additionally, by following the process through document preparation and test execution, final performance reports are easily generated.

INTRODUCTION

In a procurement world with reduced reliance on military specifications, it becomes necessary to establish an understanding between the contracting agency and the contractor to assure that the procurement successfully provides the desired system. This understanding is necessary for both the customer and the vendor to avoid costly rework, delays, and overruns that result from system development that does not meet specification intentions beyond the actual wording of the requirement.

Contraves has utilized a system of requirements traceability on several programs both with government contracting agencies as well as corporate customers that provides visibility to the test and verification requirements early in the program to assure that the system performs as expected from the beginning of the design phase. Reflecting the verification approach back to the customer provides visibility into our interpretation of the intent of the requirement, as well as the priority of the requirement. This has resulted in the delivery of hardware systems that fully meet customer expectations.

The approach used has the positive side effect of embodying principles of "design to test," "concurrent engineering," and incremental sign-off of contract requirements verification. This approach becomes a valuable tool to be included in the System Engineering Management Plan (SEMP) and can be used with a large variety of contract types including system development contracts.

As stated in IDA (Institute for Defense Analysis) Report R-338, "The role of Concurrent Engineering in Weapons Systems Acquisition:" "The mutually-defined, time-phased verification actions contained in the Systems Engineering Master Schedule provide the means for risk management of contractor progress. They are comparable or superior to those currently provided by the system of military specifications and standards" (Appendix D, section D.5). This paper describes a process that assures a suitable verification program is followed.

This process is being followed by Contraves with the delivery of a 3.67 meter reflective telescope to the Air Force Phillips Laboratory for installation on Mt. Haleakela, Hawaii. It was used previously on a 3.5 meter telescope gimbal system delivered to Phillips Laboratory

which is now in operation at the Starfire Optical Range at Kirtland Air Force Base in New Mexico. The successful application of this process in these contracts demonstrates the suitability of the methodology.

REQUIREMENT TRACEABILITY OBJECTIVE

The verification approach used by Contraves depends on matching each specification requirement with a suitable verification approach. This match-up is established early in the program, and is maintained throughout the system design, verification documentation, and test reports to provide the backbone for system sign-off.

In the case of the 3.67 meter telescope program being executed by Contraves, this matched pair of Requirements/Verification was established during the proposal effort in the form of a Compliance/Verification matrix provided to the contracting office. This matrix provided a focus for the proposal team in assuring that a verifiable design was proposed. It also furnished insight for the proposal evaluators into the suitability and credibility of the proposed system. The detail used in this matrix focused the verification on the specification parameter, rather than the specification paragraph.

Upon award of the contract, the Compliance/ Verification matrix was expanded into Verification Information Statements that provided the baseline of the requirement/ verification match-up for the rest of the program.

THE VERIFICATION INFORMATION STATEMENT

The cornerstone of the verification program discussed in this paper is the set of Verification Information Statement (VIS) sheets. Each VIS sheet, in addition to basic boilerplate information and space for customer and contractor sign-off, shows the requirement/ verification approach match-up for a given parameter.

Creation of the Verification Information Statement

An example of a VIS sheet is given in Figure 1. There is one VIS sheet for each requirement parameter, for each method of verification, and for each sequence for the verification. This topic is discussed in more detail in the section below on the Integrated Test Plan.

The requirements section is a direct, verbatim statement of the applicable specification requirement. The requirement presented on each VIS sheet reflects only one parameter. If there is more than one parameter defined in the specification paragraph, additional VIS sheets should be prepared for each parameter. By breaking down requirements in this manner, the method of verification (Analysis, Test, Inspection) and sequence of verification (Critical Design Review, In-Process Inspection or Test, Factory Acceptance Test, Qualification Test, or Site Acceptance Test) can be clearly tracked and incrementally signed off.

The Verification Approach section is a capsule description of the intended verification. The description does not get into detail about the pass/fail criteria, tooling, or procedure to be used in verification, but is presented in enough detail that scope of the verification is not ambiguous. Additionally, any test facilities, subcontract or major tooling requirement can be mentioned.

Each Verification Information Statement should be covered in no more than two pages.

At Contraves, on smaller programs, the Verification Information Statements are generated by the Systems Engineer for the program. On larger programs such as the telescope programs described in this paper, the

VERIFICATION INFORMATION STATEMENT
AEOS 3.67 Meter Gimbal and Telescope System
Specification:
F29601-92-C-0006
13 April 1993

VIS# 4.1.1C   1 OF 1   REV: A Date: 17 May 1993

Specification Paragraph Title: Clear Aperture

Parameter: Clear Aperture/ Part inspection

Method:	Configuration:	Schedule:
Examination	Coude' mirror and secondary mirror coated optics pieces.	F-IP

REQUIREMENT:

The clear aperture of the optical elements and all of the telescope system structure shall support the full primary mirror aperture over the unvignetted field of view as in section 4.1.2 at the bent Cassegrain, Nasmyth and Coude. The clear apertures associated with the optical elements are defined here as the portion of an element's surface over which the specified surface figure . . . must be met. The elements will generally be larger than their clear aperture to accommodate edge roll-off, bevels, etc. Mirrors which require an elliptical clear aperture may be made circular or polyhedral in the interest of cost effectiveness provided the excess portions do not cause vignetting . . .

VERIFICATION APPROACH:

The secondary mirrors and coude' mirrors will be examined by use of their build records to verify that they meet the drawing requirements, over the specified clear aperture, as derived for each piece by analysis on VIS 4.1.1A.

RESULTS: PASSED ________ FAILED ________ RETEST ________

COMPLIANCE (optional):

COMPLIANCE APPROVAL:

CONTRAVES INC   PHILLIPS LABORATORY

____________ DATE: ______   ____________ DATE: ______

Figure 1. Sample Verification Information Statement

VIS sheets are generated by the System Test Engineer, who works closely with the systems engineer to assure that the verification approaches are consistent with the system design concept and integration planning. On some of the more obscure requirements, it may be necessary for the system test engineer to poll the detail design staff for the verification approach. In all cases, all detail design lead engineers will be called upon to review and pass judgement on, and provide input for, the entire set of Verification Information Statements.

Review of VIS Requirements

Upon preparation of the entire set of VIS sheets, it is necessary to review the sheets to see that the verification plan is as desired. This review is done in two phases. First, the internal phase of review is performed by the contractor team to assure that the verification approach is consistent with the intended scope of the system development, and that the approach is consistent with the organization capabilities and processes. Secondly, the program should be reviewed carefully by the customer to assure that the system and verifications are acceptable.

Internal Review of VIS Requirements. As stated above, all design and production lead personnel need to be involved in the review of the entire verification package at the VIS sheet level. (This is not a trivial task on a major program. The 3.67 meter telescope program is defined by approximately 350 VIS sheets.) This review should occur at about the time of Preliminary Design Review (PDR) so that the Integrated Test Plan can be completed for submittal to the customer prior to Critical Design Review.

Review of this information is extremely critical to the success of the process. Review is neccessary to:

1. Assure that the approach on the VIS is consistent with the scope of the design. This provides a forum for discussion of the scope of the design across functions to establish concurrent engineering communication.

2. Assure that the functional disciplines are aware of the verification approach and that the completed design should pass the requirement. Functional design lead personnel are expected to accept ownership of the verification approach at this time, and there is little excuse for the failure of a test later in the program. This provides the groundwork for the "design to test" process. In many cases on the 3.67 meter telescope program, functional lead personnel have modified the design of subsystems to assure compliance as a result of this review.

3. Identify parameters and specifications that are difficult or impossible to meet. These areas are identified at the early stages of the program for communication with the contracting office for a request for a waiver, the further clarification of a requirement, or the identification of a risk area to provide extra effort, or extra development tests to verify concepts.

4. Alert the functional lead engineers to the verification process. Their people will be called on later to assist in the development of detailed plans and procedures.

5. Assure that the verification approach is tailored as much as possible to the normal operation of the organization. Keep verifications consistent with normal practice where practical. This review should identify any verification that is outside normal practice for additional attention to assure compliance.

Customer Review of VIS Requirements. Following the complete review by the internal

project team, the set of VIS sheets is submitted to the customer for review as part of the integrated test plan. The integrated test plan should be submitted to the customer prior to the PDR, the Test Plan should be presented in concept at the PDR, and the customer reviews should be completed following the PDR.

Customer review at this phase should be accomplished to:

1. Establish an understanding of the completed system operation as shown by the verification approach. This assures that the contractor interprets the specification as intended.

2. Assure that the scope of the verification is appropriate for the importance of the requirement. Many requirements in the specification are primarily background requirements of the system, but are not of primary operational importance. The contractor is going to verify these types of requirements with simplified verifications to avoid extra costs. The customer needs to concur with the contractor assessment of the requirements.

3. Assure that the verification sequence is consistent with expected performance. Customer personnel should be willing to sign-off requirements at the time (in-process, Factory Acceptance, or Site Acceptance) of the verification.

On both the 3.5 meter and 3.67 meter telescope programs, review of the VIS sheets has provided a forum for considerable lively technical discussion on many aspects of the implemented design. It has been necessary to adjust the VIS sheets to account for the mutual agreements reached during these review meetings.

The result of the review by all interested parties is that all parties concur with the scope of the test program, that it is within scope of the contract, and that it will focus on delivery of the expected system.

VERIFICATION DOCUMENTATION

The set of Verification Information Statements, as the thread of consistency throughout the project, becomes the backbone of the test documentation. Figure 2 shows the flow of documentation through the entire verification process.

Integrated Test Plan

The Integrated Test Plan is the top level controlling document for the verification program. This document should be completed at about the time of the PDR. The integrated test plan includes:

1. Verification rules of engagement, guidelines, definitions, and test overview. This information includes the following:

   a. Test failure anomaly resolution policy.
   b. Test procedure real time redline policy (if any).
   c. Definition of verification method.
   d. Description of test plans and procedures. This includes guidelines for procedure sign-off, VIS sheet sign-off, and data retention.

2. Verification flowdown matrix. This matrix is expanded from the one often provided with the specification to break down by each parameter, each method of verification, and each verification sequence. There is in essence, one matrix entry for each VIS sheet. Figure 3 shows one sheet of the Verification Flow down Matrix for the 3.67 meter telescope plan. Additional information on the matrix shows the document numbers for the test plan and procedure for each entry.

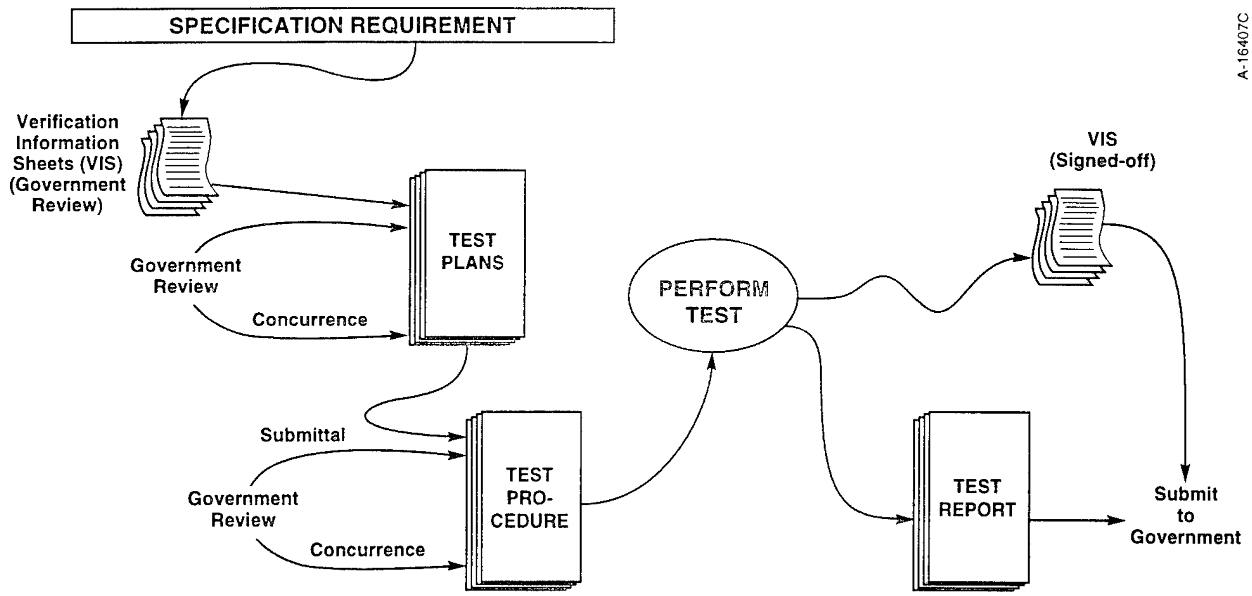

Figure 2. Document Flow

3. Requirements document breakdown diagrams. These diagrams show which matrix entries are verified during specific tests and covered by specific procedure documents. Figure 4 shows the document breakdown for the entire verification program for the 3.67 meter telescope verifications, and Figure 5 shows the VIS breakdown within the specific documents for In-Process Testing only.

   Breakdown of the VIS requirements is done to maintain manageable size of the individual documents, and to allow for incremental submittal and customer review of the documents as required by the schedule.

4. The full collection of Verification Information Statements. This is usually attached as Appendix A to the test plan. It is preceded by a Revision Status List to identify the current revision level of each VIS.

Test Plan/Specification

The test plan/specification provides exact, plain English description of the specific tests to be performed. These plans include the pass/fail criteria, any derived requirements, and the technical rationale for the validation of the test for verification of the requirements.

The test plan/specification is submitted for review as required by the customer at the same time as the procedure. The test plan/specification should describe the test completely such that review of this document should be the only review required by the customer to assure that the test program is complete and suitable.

Each section of the plan should reference the specific VIS sheet and the specification requirement. The discussion in the Test Plan describes a test that is consistent with the scope of the verification approach as shown on the VIS and that verifies the requirement completely. All pass/fail criteria, tooling, and environmental considerations are defined.

PARA NO.	TITLE	PARAMETER	VERIF. METHOD	SEQ.	PLAN #/ PROCEDURE
4.1	System Description and Performance Requirements	-	-	-	-
4.1.1	Clear Aperture	A. Clear aperture/Analysis	Analysis	CDR	TR-28291/ TR-28292
		B. Clear Aperture/Primary Test	Redundant	N/A	TP-28316
		C. Clear Aperture/Part Inspection	Examination	F-IP	TR-28296/ TP-28297
		D. Clear Aperture/Final Inspection	Examination	F-AT	TR-28300/ TP-28301
4.1.2	Field of View	Field of View	Redundant	N/A	TR-28316
4.1.3	Optical LOS Repeatability	A. Repeatability over Temperature	Analysis	CDR	TR-28291/ TR-28294
		B. Repeatability	Test	F-AT	TR-28300/ TP-28303
		C. Site Repeatability	Test	S-AT	TR-28306/ TP-28311
4.1.4	Angular Velocity and Acceleration Profiles	A. Profiles, Factory	Test	F-AT	TR-28300/ TP-28305
		B. Profiles, Site	Test	S-AT	TR-28306/ TP-28310

Figure 3. Verification Flowdown Matrix (Partial)

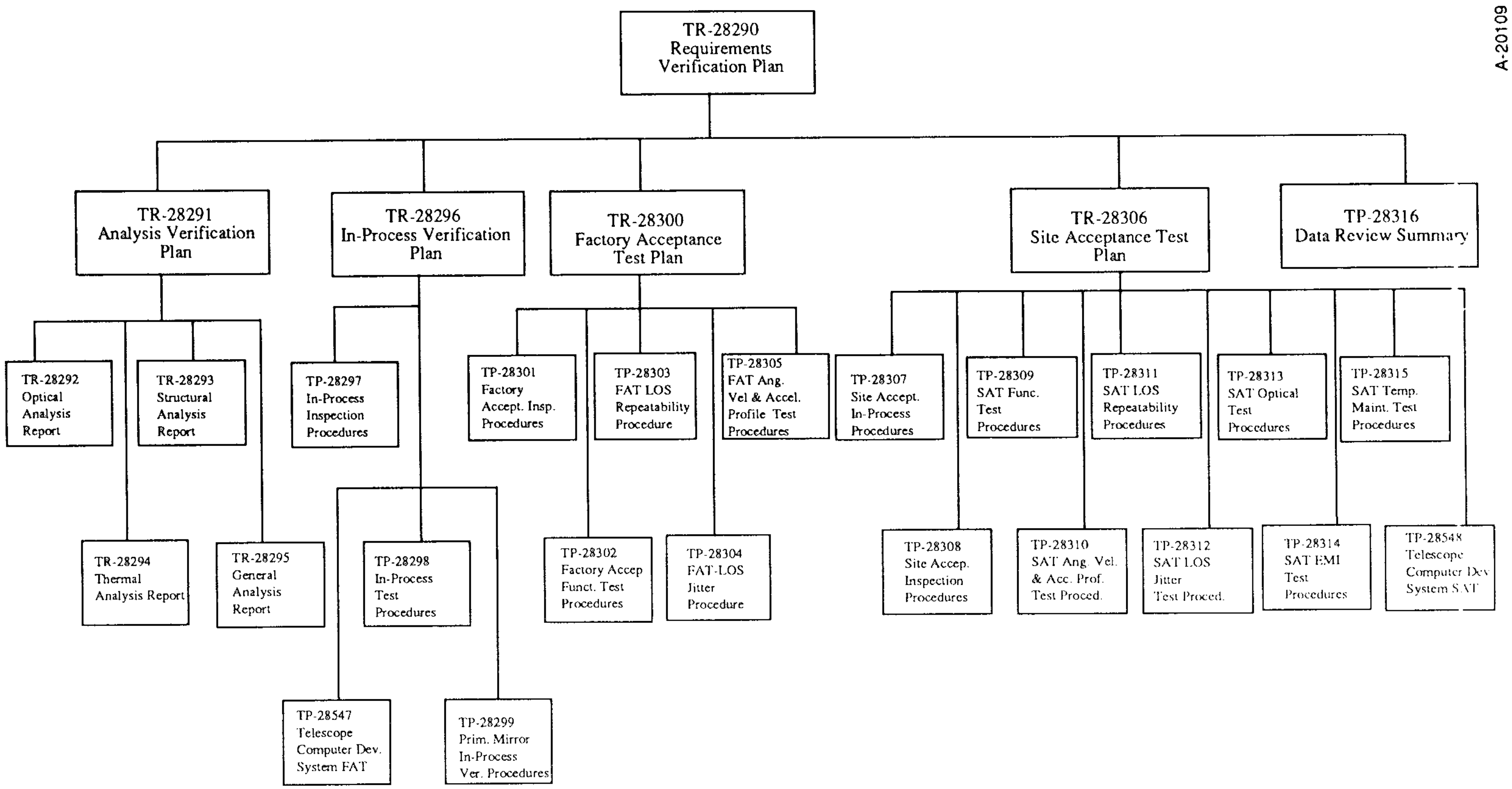

Figure 4. Document Breakdown

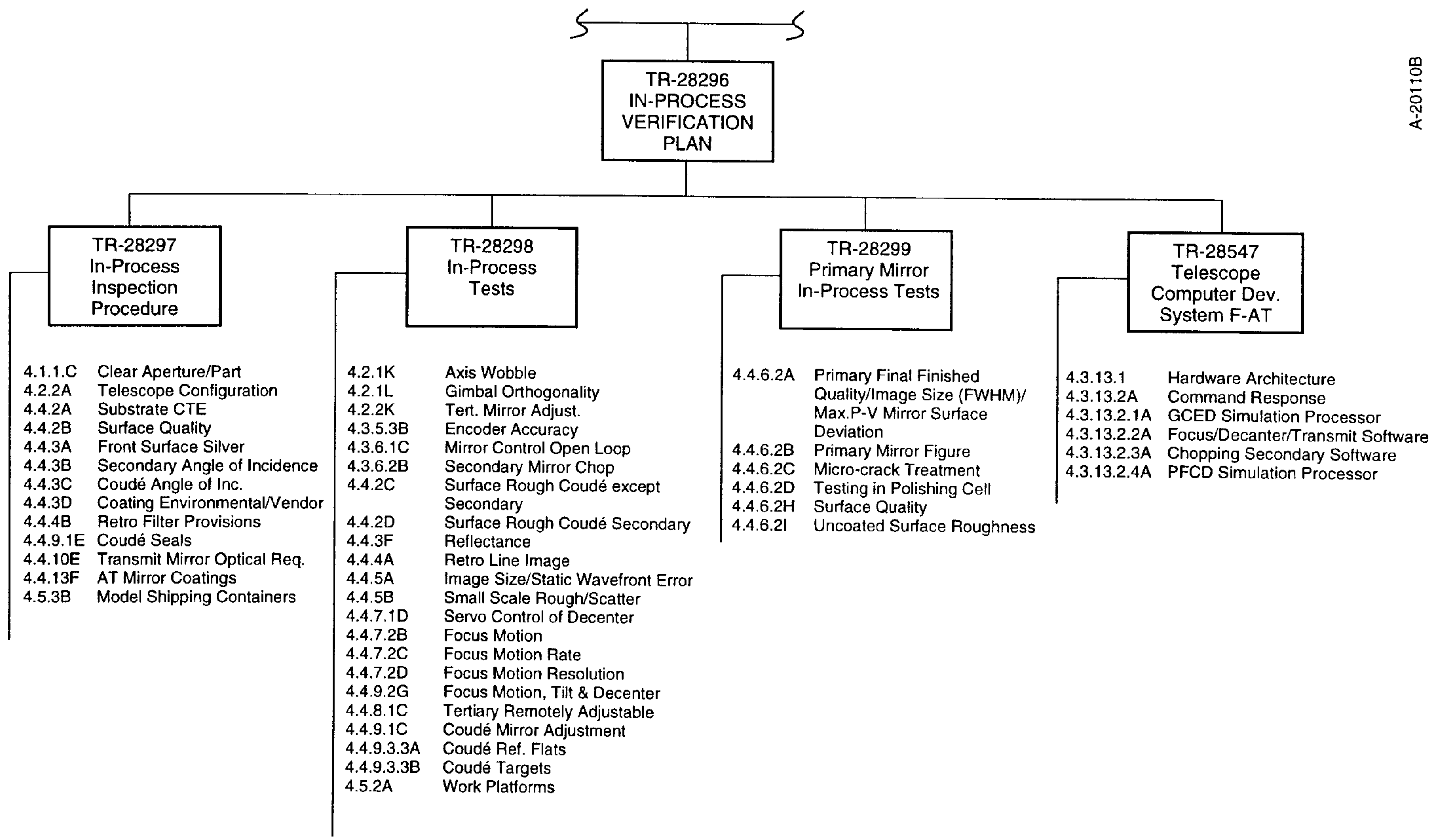

Figure 5. 3.67 Meter Telescope In-Process Verification Breakdown

Customer review of the test plan documents should be complete to assure the actual design of the specific tests is as expected.

Test Procedures

The test procedures are step by step descriptions of the necessary operations for performing the tests as defined in the test plan. The detail of the procedures is such that the test is repeatable, but excess detail above that necessary to be performed by a qualified operator is not necessary. Copies of the applicable VIS sheets are included in an appendix to the procedure, and are available for sign-off at the completion of each section.

Test procedures provide locations for recording data and check-off (initial and date) of steps, and sign-off of the critical parameters by a qualified operator or cognizant engineer. At the end of each verification, the procedure is signed off by a cognizant engineer and the System Test Engineer as being complete and acceptable as final verification. Pass/fail criteria are identified beside each critical data entry.

Customer review of the procedures prior to testing is performed to assure that the final procedure properly executes the test designed in the test plan/specification, and again that the verification is in accordance with the approach as defined by the VIS sheet.

Customer witness of the testing is sometimes required by the contract. In this case, there should also be a location at the end of each verification procedure for the sign-off by customer witness. In other cases, customer witness of the actual test may be optional. In this case, there is no sign-off of the procedure by the customer, but sign-off of the VIS sheet is completed following customer data review of the completed procedure. The last step of each section of the procedure calls for the sign-off of the respective Verification Information Statement.

The data copy of the procedure is maintained in a loose leaf binder with space to add additional data, and a section for added test notes at the beginning.

Test Reports

With the proper preparation of procedures and careful execution of tests, test reports are easy to prepare. The test report for each individual test procedure is completed by providing a brief summary of significant events during testing gleaned from the notes at the front of the procedure and a summary table that compares the specified requirements for each relevant VIS sheet covered with the actual results of the test. Attached to this brief summary is a copy of the "as tested" procedure, notes, and signed VIS sheets.

Summary Test Report

The Summary Test Report is a document that contains a checklist of all VIS sheets, defined as to the sequence of performance, and space for recording the revision level of each VIS sheet signed off. Figure 6 shows one page of the checklist used on the 3.67 meter telescope showing the partially approved level of the verification program. This document is prepared, published, and submitted to the customer following the general concurrance of all parties with the Integrated Test Plan.

As the procedures are completed and the VIS sheets are signed off, copies of the completed VIS sheets are attached to the summary test report document and the respective line item is completed and initialed.

Following all testing, the final test report summary is completed by preparing a brief summary overview of all testing, and combining all the individual report compliance tables into a complete table of all VIS specification values and actual results. This, with the VIS checklist and signed VIS sheets

Para. No.	Title	Parameter	Verif. Document	VIS REV.	Sequence 1	2	3	4	Complete Init/Date
4.1	System Description and Performance Requirements	—	—	—		—			
4.1.1	Clear Aperture	A. Clear Aperture/Analysis	TR-28292	A	X	—	—	—	TRB / 8/5/94
		B. Clear Aperture/Primary Test	Table 4-1	____		N/A			____ / ____
		C. Clear Aperture/Part Inspection	TP-28297	____	—	X	—	—	____ / ____
		D. Clear Aperture/Final Inspection	TP-28301	____	—	—	X	—	____ / ____
4.1.2	Field of View	Field of View	Table 4-1	A		N/A			TRB / 8/5/94
4.1.3	Optical LOS Repeatability	A. Repeatability over Temperature	TR-28294	A	X	—	—	—	TRB / 8/5/94
		B. Repeatability	TP-28303	____	—	—	X	—	____ / ____
		C. Site Repeatability	TP-28311	____	—	—	—	X	____ / ____
4.1.4	Angular Velocity and Acceleration Profiles	A. Profiles, Factory	TP-28305	____	—	—	X	—	____ / ____
		B. Profiles, Site	TP-28310	____	—	—	—	X	____ / ____
		C. Max Velocity and Acceleration	TP-28302	____	—	—	X	—	____ / ____
		D. Maximum Velocity and Acceleration	TP-28309	____	—	—	—	X	____ / ____
4.1.5	Angular Position Sensor LOS Jitter	Powered Jitter	Table 4-1	____		N/A			____ / ____
4.1.6	Optical Quality	Optical Quality	Table 4-1	____		N/A			____ / ____
4.1.7	Reliability and Maintainability	Mission Reliability	TP-28295	—	X	—	—	—	TRB / 1/20/95
4.1.7.1	Reliability	A. 4.1.7.1.1 Reliability Program	TR-28295	B	X	—	—	—	TRB / 1/20/95

Figure 6. Verification Summary Checklist

attached, completes the test report for submittal with the hardware.

PITFALLS AND PROBLEM AREAS

As with any process, care must be excercised to assure proper operation of the system. Some of the areas of concern are discussed below.

Inattention

Probably the worst thing that can happen to this process is to not pay attention to detail. If the customer does not pay attention to the Integrated Test Plan at the time of submittal, there is a high probability that the final product will not perform as expected due to a misinterpretation of the specification.

If the design team does not adaquately review the VIS sheets at the first development, it is likely that the verification may require more resouces than necessary, and may not fit the normal operation practice of the organization.

Care in Preparation of the Specification

It has been our experience on several programs that the customer's first reaction to the Integrated Test Plan is that the specification does not really ask for what is desired. This results in the revision of the specification by the contracting office early in the program. (It is better that this be discovered early than late, so the process is doing its job.) To avoid this pitfall, it is necessary for the contracting office to excercise care in the development of the specification.

Care in Execution of the Design

It is extremely important that the finished product perform as required by the verification approach. Many times, during internal review of the VIS sheets, we find the engineering staff taking notes in certain areas of the VIS sheets. These notes result from the initial concept not being easy to verify, or not being fully compliant with the requirements. These notes are then translated into design modifications that bring the system into compliance. (Again, this is an example of the system performing properly.) If, on the other hand, the internal review of the VIS sheets is not adaquate, the design may end up being inadaquate, and the resulting failed condition will be extremely obvious. (Again, the process is working, now for the benefit of the customer.)

Product Development in Terms of Mission Objectives

Our experience to date with this process is applicable to systems that are contracted with a clearly defined operational specification. In these areas, this process works extremely well.

Some contracts are issued with a "mission objective" requirement, rather than a performance specification. This process is as yet untried on this type of contract. This type of contract requires that the contractor provide the additional step of validating the derived performance specification against the mission objective. It seems that the VIS type process could be useful, but the quantum leap from verification of exact specification requiremnts to the validation of mission requirements might be difficult for both customer and contractor to make in one step.

CONCLUSION/SUMMARY

By using this process on the 3.5 meter telescope project, delivered in 1992, Contraves was able to focus the verification process on detailed specification issues. This gave the customer confidence that upon completion of the sign-off of all the VIS sheets, the program was successfully completed. In this case, by the time of final system integra ion on site, and completion of training for cus ɔmer personnel in the operation of the system, the actual

performance of the Site Acceptance Test to verify system performance was completed with customer witness in approximately 4 hours. At this time, without additional technical issues being discussed, the DD-250 was signed, transferring ownership of the system to the government.

Logicon RDA has been involved in the verification process of both the 3.5 meter telescope and the current 3.67 meter telescope project as technical consultant to the Government. Engineers involved in this process from Logicon RDA have indicated that the VIS system of requirements verification provides an exemplary method of assuring that all contract specification requirements are compliant and that nothing is being omitted or neglected by either customer or contractor effort.

In our experience with this process on several additional programs, it has been observed that the VIS system provides careful focus of the verification on specific issues to be delt with individually, reducing confusion in the verification process. Many first reactions from customer personnel to this process is that it is excessively cumbersome and tedious to complete in detail. However, by the completion of the process, all customers have aggreed that it provides the confidence that the delivered system is as ordered, and that when all the VIS sheets are signed, the requirements are completed.

In the case of the 3.67 meter telescope now being completed, the project management and technical people for the customer contracting office have changed twice since the inception of the program. The mutual acceptance of the VIS process has provided a common denominator for the program to prevent excessive cost growth and maintain the program with minimal scope expansion.

Contraves has found this process to be extremely effective in delivering hardware to the customer that meets their expectations.

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THE MISSING LINK!

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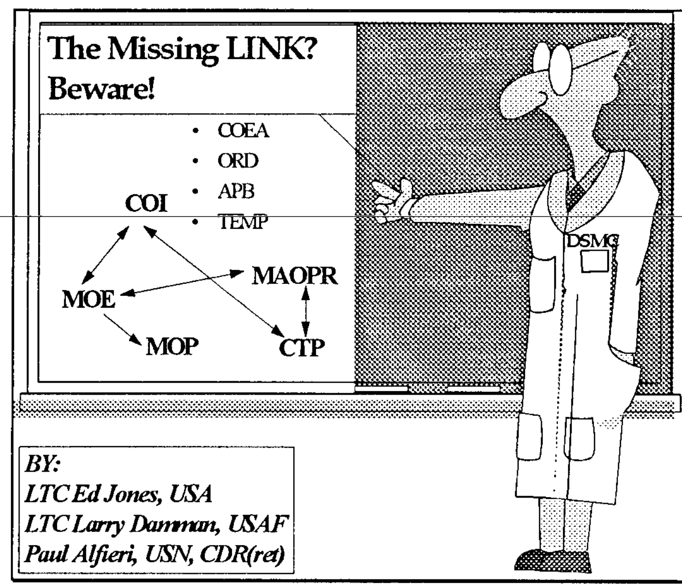
ABSTRACT

Professors in the Test and Evaluation Department at the Defense Systems Management College have the opportunity to work with test and evaluation professionals from all the services. One common area of confusion is how to establish required linkages between performance parameters in the following key Department of Defense (DoD) mandated acquisition documents:

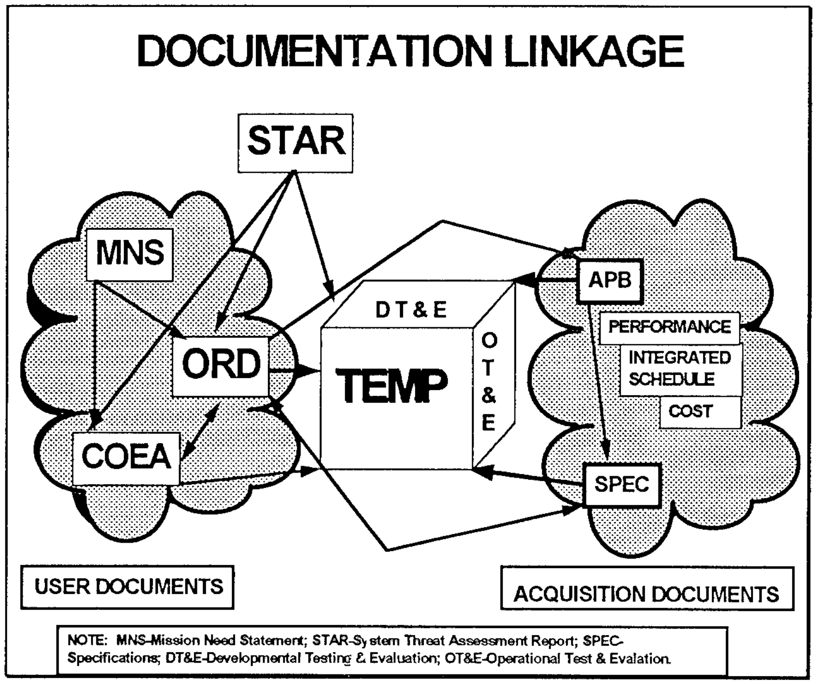
- Cost and Operational Effectiveness Analysis (COEA).
- Operational Requirements Document (ORD).
- Test and Evaluation Master Plan (TEMP).
- Acquisition Program Baseline (APB) (Includes Concept, Development and Production Baselines).

In addition to preparing the mission need statement (MNS), the user community prepares the ORD. Each service designates which agency or staff prepares the COEA. Acquisition professionals prepare the APB and enabling contractual instruments such as system performance specifications to procure a new system.



INTRODUCTION

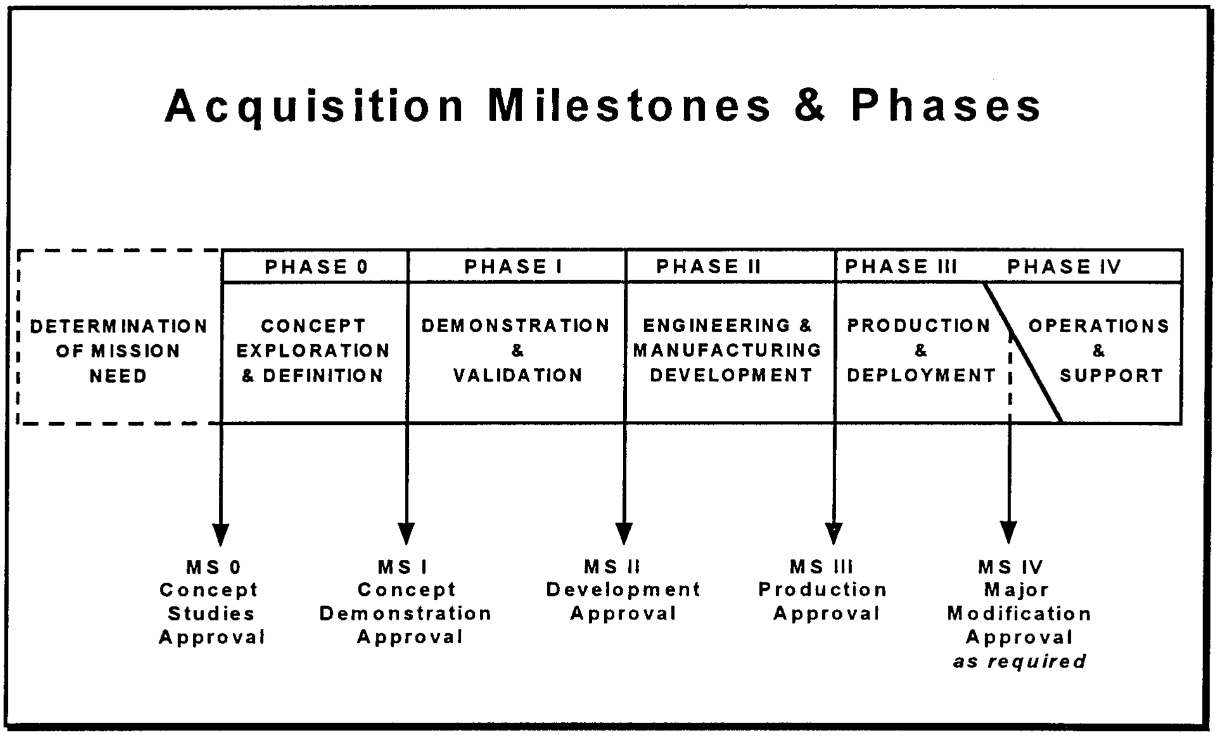
Figure 1 (Documentation Linkage)



Although acquisition professionals have the lead in preparing the TEMP, user representatives also play a major role in its preparation by participation in the test integration and planning working groups. (TIWGs & TPWGs) The Operational Test Agencies (OTA) and service designated combat developers often write the portions of the TEMP that pertain to operational testing. During the acquisition of a new system, the TEMP provides a linkage between those documents that the user prepares and those that the acquisition community prepares. Figure 1 depicts the key acquisition documents, other key supporting documents and their linkages.

Figure 2 depicts the acquisition cycle and the decision points where the key acquisition documents are reviewed. The MNS is prepared before milestone 0. The APB, ORD, TEMP and COEA are prepared during phase 0. These key acquisition documents are updated and reviewed by decision makers at each subsequent milestone.

Figure 2 (Acquisition Process)



In a March 1992 memorandum, the Under Secretary of Defense for Acquisition mandated the following:

> **1. Linkage should exist between the COEAs and test and evaluation. Particular emphasis must be placed on linkage between measures of effectiveness/performance and performance parameters that define military utility of a system. In particular, the MOEs, MOPs, and criteria in key acquisition documents are to be consistent.**
>
> **2. The TEMP should document how the COEA MOEs and related MOPs will be addressed in test and evaluation.**

Performance measurements (or parameters) used in the Cost and Operational Effectiveness Analysis (COEA) should have corresponding system specific performance parameters that are tested and evaluated during developmental and operational tests. The milestone decision authority (MDA) must ensure that the proposed system remains the most cost effective alternative. If a proposed system fails to meet any of the specified performance thresholds in a COEA, it is possible that another alternative may be more cost effective. Changes in requirements and associated parameters in the Operational Requirements Document (ORD) also have the potential to invalidate the results of the COEA. When an updated COEA indicates that a system under development is no longer the most cost effective alternative, the milestone decision authority (MDA) must determine whether to terminate, to modify or to continue the program in development. The performance parameters and issues that are tested should be directly derived from the required

capabilities in paragraph four of the ORD. The key parameters tracked in the acquisition program baseline (APB) should be selected from the same key performance parameters. If the parameters in the APB are not in the other key acquisition documents, the milestone decision authority may have little or no supporting test data to evaluate the APB key parameters.

This article clarifies guidance from the DoD 5000 series publications and provides hints (hopefully helpful) on implementation. Present performance parameter terminology used throughout this article is defined in an endnote.[1] We will recommend a simplified performance parameter terminology that has parameters that are inherently linked to each by definition. Today, acquisition professionals must **infer** linkages among performance parameters. We will propose a process to establish and maintain performance parameter linkages among the key acquisition documents. Some of the recommended changes may be appropriate for formal inclusion in the next revision of the DoD 5000 series publications. The goal of these proposed changes and simplifications is to ensure that "truly critical" `system performance parameters are correctly specified and consistently applied throughout the key acquisition documents. **"Truly critical"** parameters (as used in this article) are defined to be those parameters with thresholds that must be met for a system to successfully perform a mission essential task.

To accomplish the preceding stated goals, this article will:

(1) Clearly state the performance parameter specification and linkage problem and its impact on the acquisition system.

(2) Review current performance parameter terminology and implementing policies in the DoD 5000 series publications.

(3) Simplify the DoD 5000 series performance parameter terminology and establish inherent performance parameter linkages among the key acquisition documents.

(4) Demonstrate how to specify performance parameters and to ensure their linkage among key acquisition documents.

STEP 1
PROBLEM STATEMENT

What are the "truly critical" performance parameters that are to be specified in the key acquisition documents? **What linkages exist between these performance parameters among the key acquisition documents?** Performance parameters that lack precision and are not consistently specified among the key acquisition documents are a "formula for disaster". This "formula for disaster" consists of the following three key ingredients:

(1) ***UNCERTAINTY AS TO WHAT PERFORMANCE IS "TRULY CRITICAL" IN SYSTEM DESIGN***: When performance parameters lack precision and are inconsistently specified, the system engineer must decide what is "truly critical" and what is "nice to have" when writing the contractual system performance specifications. This practice may result in an unstable design process. System engineers specify "truly critical" performance parameters to be key design objectives to which

they optimize the overall system design. Inconsistently specified performance parameters among the key acquisition documents promote confusion as to which performance objectives are central to the system design. As the "truly critical" design parameters are discovered, the system engineer must enact engineering change proposals to ensure required performance or characteristics are incorporated into the system design.

(2) ***UNCERTAINTY AS TO WHAT PERFORMANCE IS "TRULY CRITICAL" FOR TEST AND EVALUATION PLANNING***: Consideration should be given to the decision of what performance parameters to test and how much testing is necessary. Inconsistent or imprecise performance parameters may result in testing the wrong parameters. Tests that produce data to evaluate less than "truly critical" performance parameters not only waste resources, but also diverts the decision maker's attention from evaluating the more important "truly critical" performance parameters. Imprecision and inconsistency among performance parameters make it difficult to determine which tasks and performance parameters are "truly critical" and for which decisions?

(3) ***UNCERTAINTY AS TO WHAT PERFORMANCE IS "TRULY CRITICAL" DURING MILESTONE DECISIONS:*** The key parameters that are listed in the acquisition program baseline (APB) have thresholds that if not met require a reevaluation of alternative concepts and/or design approaches. If the key parameters are different from the parameters listed in the TEMP, the milestone decision authority (MDA) will probably have insufficient data to make sound decisions. It is also possible that the MDA will approve a system to proceed into the next acquisition phase when that system fails to achieve thresholds for "truly critical" performance parameters.

For example, the ORD may list a critical system characteristic (CSC) to be that a communications system must provide voice communications for ranges up to 35 kilometers under severe jamming conditions as defined in the system threat assessment report (STAR). Present DoD guidance does not mandate that each critical system characteristic (CSC) be listed in the TEMP as critical operational issues (COIs), minimum acceptable operational performance requirements (MAOPRs), critical technical parameters (CTPs) or in the acquisition program baseline (APB) as key parameters. If this CSC is not specified to be a COI, MAOPR, key parameter or CTP, it is likely that test planning will not place the appropriate emphasis and resources into generation of test data to adquately assess this critical system characteristic. The milestone decision authority might decide that the program should enter the next acquisition phase without adequately considering voice communications under severe jamming. Assuming this CSC to be "truly critical", all the key acquisition documents should include this CSC as a "truly critical" parameter. One central ingredient is required: ***We must have a performance parameter terminology that is simple, pricise, consistent among key acquisition documents and identifies "truly critical" performance parameters***

STEP 2: CURRENT TERMINOLOGY & POLICY

The next step is to review the performance parameter terminology and implementing policies and procedures as prescribed in the current DoD 5000 series publications. Figure 3 lists the performance parameters that are currently used in the key acquisition documents.

Figure 3 (Performance Parameters)

COEA	ORD	TEMP	APB
Functional Objective (FO)	Performance (operational effectiveness and suitability) capabilities and characteristics	Critical Operational Issue (COI)	Key Parameters
Measure of Effectiveness (MOE)	System Performance	Minimum Acceptable Operational Performance Requirement (MAOPR)	
Measure of Performance (MOP)	Logistics	Critical System Characteristic	
	Critical System Characteristic	Critical Technical Performance (CTP)	

Decision makers use the functional objectives (FO), measures of effectiveness (MOE), and the measures of performance (MOP) in the cost and operational effectiveness analysis (COEA) to predict which is the most cost effective concept to meet a validated mission need. On the other hand, system engineers, test managers, decision makers and others use the critical operational issues (COI), the minimum acceptable operational performance requirements (MAOPRs) and critical technical parameters (CTPs) to determine whether a system meets the user's requirements.

Except for the critical system characteristic (CSC), each key acquisition document uses uniquely defined performance parameter terminology. Although the DoD 5000 series publications do indicate from where performance parameters are to be derived, they do not clearly specify the inherent linkage relationships between the various performance parameters. The list of effectiveness and suitability parameters and constraints listed in the operational requirement document (ORD) are the source for MAOPRs. The critical system characteristics (CSCs) listed in the ORD and the technical performance measures (TPMs) provided in the systems engineering management plan (SEMP) are the source for critical technical parameters (CTPs). One problem area common to all the services is confusion over the relationship (or linkage) between critical technical parameters (CTPs) and the minimum acceptable operational performance requirement (MAOPRs). A wide diversity of opinion exits as to when a critical system characteristic (CSC) is to be MAOPR verses a CTP. Those parameters that can not be tested without extensive instrumentation and under highly controlled conditions are often designated to be CTPs. An example CTP could be vehicle mobility under specific road conditions with specific grades. Those parameters that are highly dependent on operational conditions are often designated to be MAOPRs. An example could be the mean time between operational mission failure for a radio.

Questions to be answered include: (1) Should CTPs be defined to support the evaluation of MAOPRs and COIs? (2) Does a CTP best correspond to the COEA's measure of effectiveness (MOE) or to the measure of performance (MOP)? (3) Are all critical system characteristics (CSCs) valid candidates to become critical technical parameters (CTPs)? Our review of the DoD 5000 series publications produced no definitive guidance and few clues as to the correct answer to the preceding questions and issues. Part 7 of DoD 5000.2M (TEMP writing guidance) states: "Discuss the relationship between the critical technical parameters and the minimum acceptable operational performance requirements in the Operational Requirements Document." This relationship is uncertain and few (we have not found any!) TEMPs discuss the relationships between MAOPRs and CTPs. We will recommend answers to the preceding questions, but first we should take a more detailed look at the source for MAOPRs, CTPs, and key parameters. That source is the paragraph four of the ORD.

DoDI 5000.2 {Part 4} cites the ORD to be a source for MAOPRs, CTPs, and key parameters. In the ORD, the three categories of required capabilities are: (1) **System Performance**; (2) **Logistics and Readiness** and (3) **Critical System Characteristics.** Figure 4 depicts the performance parameter categories with examples extracted from DoD 5000.2M. System performance parameters such as range and speed are not critical system characteristics, but are listed in a separate category titled "system performance". All parameters in paragraph four are MAOPR candidates while the critical system characteristic (CSC) is the CTP source. Therefore, it is likely that some MAOPRs and CTPs will be derived from the same critical system characteristic. Use of the technical performance measures (TPMs) from the SEMP as a CTP source complicates the specification process. As presently defined, the TPM can be any type of parameter and has no limitations on sources. TPMs could include all the parameters in paragraph four of the ORD or exclude them all. It is possible that many (or all) of the MAOPRs and CTPs will be the same parameter.

Figure 4 (ORD PARAMETERS)

(ORD)Critical System Characteristics & System Performance Parameters

• Critical System Characteristics	• System Performance Parameters
– ECCM	– Range
– Safety Parameters	– Accuracy
– Electromagnetic compatiability	– Payload
– Survivability(nuclear, etc..)	– Speed
– Transportability	– Mission reliability
– Energy efficiency	• Logistis & Readiness
– Interoperability	–Mission Capable Rate
– Standardization	–Operational Availability
	–MTBF
	–MTTR

How do all the performance parameters, characteristics, requirements and issues tie together? Figure 5 depicts the linkages implied and directed by the current DoD 5000 series publications. Solid arrows depict the sources for performance parameters. The dotted line indicates that critical system characteristics are the same in the ORD and TEMP.

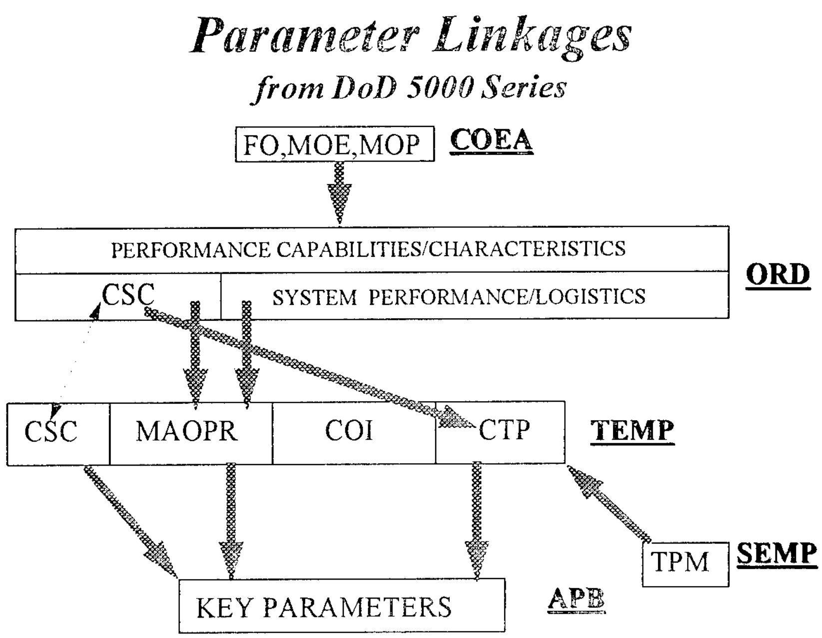


Figure 5 (Performance Linkages)

Using the current performance terminology, we will outline the process to establish "truly critical" performance parameters.

1. **Establish the functional objectives (FOs), measures of effectiveness (MOEs) and measures of performance (MOPs).** In theory (in practice all the key acquisition documents are often prepared simultaneously), the COEA is one of the first documents to be drafted. It provides analysis to select a preferred system concept. The phase 0 COEA is based on the mission need statement (MNS) and has the following goals:

. Identify the performance and cost advantages and disadvantages between proposed ystems over the existing system and /or a modified existing system.
. Broadly define the system characteristics needed in the new system.
. Select the preferred alternative to carry into phase I of the acquisition cycle.

2. **Derive the required capabilities in the ORD from the mission need statement (MNS) and the COEA**. The MOEs and MOPs are candidates for MAOPRs and CTPs. The technical performance measures (TPMs) in the System Engineering Management Plan (SEMP) {when it exists} are CTP candidates. In paragraph four of the ORD, list the required capabilities in the prescribed format. Identify which parameters are to be MAOPRs and CTPs.

Figure 6 (ORD Characteristics)

(ORD)Critical System Characteristics
& System Performance Parameters

• Critical System Characteristics – ECCM(MAOPR &CTP) – Safety Parameters – Electromagnetic compatiability – Survivability(nuclear, etc..) – Transportability(CTP) – Energy efficiency – Interoperability(CTP) – Standardization(MAOPR)	• System Performance Parameters – Range(MAOPR & CTP*) – Accuracy(MAOPR) – Payload(MAOPR &CTP*) – Speed(MAOPR &CTP*) – Mission reliability(MAOPR) • Logistis & Readiness –Mission Capable Rate(MAOPR) –Operational Availability –MTBF(MAOPR) –MTTR(CTP*)

CTP*-SPECIFIED AS TPM IN SEMP.

3. **Directly extract the key parameters from the ORD into the APB**. The milestone decision authority (MDA) approves the specification of key parameters in the APB.

4. **Define the critical operational issues (COIs).** COIs are questions that when answered provide a basis for the operational test agency (OTA) and the Director of Operational Test and Evaluation (DOTE) to assess operational effectiveness and suitability. The COEA functional objectives (FOs) are COI candidates. The functional objectives (FOs) as defined in the COEA are the mission essential tasks that a system must perform.

The following recommended hints can be used to establish parameter linkages and to improve the overall performance parameter specification process:

a. Form an integrated product team to coordinate and draft the key acquisition documents. During step 4, we will provide a detailed team composition and team charter.

b. Expand the critical technical parameter matrix (presently required in the TEMP) to include the MAOPRs. In the past, this table only tracked developmental testing. Combining key operational and development test events into one matrix provides test planners/managers and decision makers a more complete and integrated status report on how the system is performing. Figure 7 depicts an example matrix.

Figure 7 (CTP & MAOPR Test Status)

CTP and/or MAOPR	Test	(Threshold/ Objective) {One # is threshold}	Location	Schedule	Decision Supported	Demonstrated value
Detection Range (MAOPR & CTP)	D/V DT E/MD DT PQT	7.0 Km 9.5 Km 10.0 Km/11Km	ABC Range	1Q FY-XX	M/S II	7.8Km 9.8Km 11.2Km
Operational Availability (MAOPR)	IOTE	95%/98%	Fort Hood, TX	3Q FY-XX	M/S/III	

c. Use the following guidelines to specify MAOPRs and CTPs:

(1) Designate top level performance and suitability parameters to be MAOPRs. Top level means that the parameter measurement is not used to calculate or predict another parameter measurement. For example, probability of shooting down an incoming enemy aircraft could be a MAOPR.

(2) Designate second level performance parameters that support the calculation or prediction of a MAOPR to be a CTP. For example, probability of radar detection and probability of successful missile launch could be critical technical parameters that support the prediction of a MAOPR for probability of shooting down an incoming enemy aircraft.

(3) Do not restrict specification of MAOPRs to those parameters that can be adequately tested in operational testing and CTPs to those parameters that can be adequately tested in developmental testing. Problems in testing MAOPRs and CTPs can be adequately addressed in the test limitations part of the test report.

d. Ensure that each MAOPR supports the assessment of one or more COIs. A MAOPR that does not support a COI indicates a problem. Either the MAOPR is not a "truly critical" parameter or a COI is missing and needs to be assigned.

e. Although presently not required in the ORD, parameter linkages among the COIs, MAOPRs, and CTPs should be depicted in paragraph four. An example method to depict parameter linkages is to use a three digit numbering system. For example, CTP 3-2-1 denotes CTP number 1 that supports the calculation of MAOPR 2 that supports the assessment of COI 3. An expanded example of the recommended numbering system is below:

COI 1: Does SINCGARS provide reliable voice communications with adequate range to support command and control for forward deployed combat forces at division level and below?

MAOPR 1-1: Aggregate voice message completion rate (MCR) within a division with jamming. {Threshold 80%; Objective 90%.}
{NOTE: MAOPR 1-1 is a weighted average of CTP demonstrated values.}

CTP 1-1-1: Voice MCR at 10, 20, 25, 30, 35 Kms with severe jamming levels. {Threshold 50%; Objective 55%.}

CTP 1-1-2: Voice MCR at 10, 20, 25, 30, 35 Kms with moderate jamming {Threshold 80%; Objective 90%.}

CTP 1-1-3: Voice MCR at 10, 20, 25, 30, 35 Kms with low jamming {Threshold 85%; Objective 95%.}

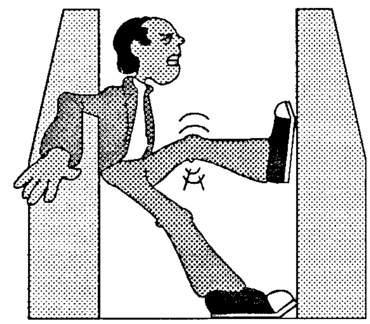
f. To assess whether parameter linkages exist between the TEMP and the COEA, the test manager should construct a parameter correlation matrix. This matrix should be added as an appendix to the TEMP.

Figure 8 (Parameter Correlation Matrix)

COIs (TEMP PARA #s) (Abbreviate w/reference #)	COEA MOE/ MOP	MAOPRs (TEMP PARA #)	CTPs (Ref # from Fig 1 of TEMP)	ORD PARA #	APB	TEST
(4.b.(1)) Is voice communications adequate to support combat operations for forward deployed combat forces?	Voice MCR rate in a realistic jamming environment.	(1.c) Provide sufficient jamming resistance to provide adequate voice commo	(4) Voice Jamming MCR.	4a(1)	YES	DT-2 DT-3 IOTE
	Voice MCR rate with no jamming.	(1.d) Provide adequate voice commo with no jamming.	(5) Voice MCR with no jamming.	4a(2)	YES	DT-1 DT-3 IOTE

STEP 3: SIMPLIFICATION & LINKAGE

Enough discussion of the complications, unanswered questions, and imprecise definitions! What should be done? We need a "Brave New World" in the establishment, tracking, and linking of performanceparameters. ***A new way of doing business is required.*** The key is to consistently apply a simplified performance parameter terminology that is common (or inherently linked) among all of the key acquisition documents. Whenever possible, the parameters should be same. First we must simplify the DoD 5000 series performance parameter (and issue/task) terminology.



The critical operational issue (COI) provides criteria to assess operational effectiveness and suitability as demonstrated during an Initial Operational Test and Evaluation (IOTE). COIs are normally questions that have a yes or no answer. Unlike the MAOPR and CTP, the COI has no DoD 5000 series mandated sources. Its derivation is highly reliant on the good judgment of the writer. The TEMP is the only key acquisition document to list the COIs. Because the COI lacks inherent relationships with other performance parameters and its derivation source is uncertain, it does not meet our standards for simplicity and inherent linkage. We will replace the critical operational issue (COI) with a new top level performance requirement criterion that is named the critical operational task (COT).

New TOP Level Performance Parameter Definition:{ORD, TEMP}

CRITICAL OPERATIONAL TASK (COT)- A COT is a statement describing, in quantitative or qualitative terms, a top level mission essential task that a specific system will be expected to perform in order to satisfy a task implied or explicitly stated in a Mission Need Statement (MNS). The overall system effectiveness and suitability is evaluated by assessing the degree to which the COTs are successfully accomplished. Critical operational parameters (COPs) are specified to assess the degree to which a COT is accomplished. COTs correspond to the non-system specific functional objectives (FO) in the COEA.

The system specific critical operational task (COT) corresponds to the non-system specific functional objective (FO) in the COEA. The definition for a FO follows:

New TOP Level Performance Parameter Definition:{COEA}

FUNCTIONAL OBJECTIVE(FO)- A FO describes, in quantitative or qualitative terms, a top level mission essential task that the alternative systems will

be expected to perform in order to satisfy a task implied or explicitly stated in a Mission Need Statement (MNS). It is stated to be applicable to all alternatives that are being considered in the Cost and Operational Effectiveness Analysis (COEA). Measures of effectiveness (MOEs) are specified to assess the degree to which a FO is accomplished

We have already discussed the problems that the services have encountered in using the minimum acceptable operational performance parameter (MAOPR) and the critical technical parameter (CTP). We will replace the MAOPR with a new performance parameter that is named the critical operational parameter (COP). The critical operational parameter (COP) is a system specific measure of effectiveness or suitability that is defined to assess a COT

New Second Level Performance Parameter Definition:{ORD, TEMP, APB}

CRITICAL OPERATIONAL PARAMETER (COP) - A COP is a quantitative or qualitative measure of physical performance or suitability that indicates the degree to which a specific system successfully performs a critical operational task (COT) under specified conditions. Each COP should normally have specified thresholds and objectives and will normally correspond to a measure of effectiveness (MOE) in the COEA.

COPs provide data and information to assess whether a system can perform a COT. Using test results in which COPs were tested, the decision maker makes an informed judgment as to whether a COT is successfully performed. The COT does not normally have associated thresholds and objectives. The COP replaces the MAOPR and CTP (as previously defined). Whenever possible, COPs are tested during both operational and developmental testing. **The ideal situation is to test all "truly critical" performance parameters under operational conditions.** The tester, engineer, and user ultimately want to know how the system will work during combat, not in a lab. Unfortunately, technical limitations (required instrumentation etc.) and resource constraints often limit the extent to which testing can be operational. Today, CTPs are normally defined to test those parameters that are to be tested in developmental testing. We will no longer make a distinction in specifying a parameter based on which type of testing to be used to assess that parameter. We want to know how a system performs under operational conditions. Some COPs that require extensive instrumentation and highly controlled test conditions can only be adequately tested during developmental testing. In this case, the evaluator must extrapolate the developmental test results into an operational scenario. For major program milestone decisions, the Director of Operational Test and Evaluation (DOTE) with input from the

Director Test, System Engineering and Evaluation (DTSEE) and the services' Operational Test Agencies must approve to what extent COPs can be evaluated using results from less than fully operational testing. These limitations must be listed as a test limitation in the test report and in the system evaluation. Whenever practical, the COPs are to be tested during the dedicated IOTE to verify test results from earlier developmental and operational testing. When testing COPs during a dedicated IOTE, the title 10 (USC) constraints on using contractors **REMAINS** in effect. The "Brave New World" recommends changes to the DoD 5000 series publications. Recommended changes in law, although desired, are not required.

The measure of effectiveness (MOE) in the COEA corresponds to the system specific COP. It is defined as follows:

New Second Level Performance Parameter Definition:{COEA}

MEASURES OF EFFECTIVENESS (MOE) -- A MOE is a quantitative or qualitative measure of physical performance or suitability that indicates the degree to which a system successfully performs a functional objective (FO) under specified conditions. Each MOE should normally have specified thresholds and objectives. The MOE is applicable to all alternative systems that are being considered during the COEA. The MOE corresponds to the critical operational parameter (COP) which is system specific.

A performance parameter that is defined to support the assessment of a critical operational parameters (COPs) during test and evaluation is designated to be a critical parameter (CP). The CP includes both system performance and supportability parameters. It is tested during developmental and operational testing in the same manner as previously discussed for the COP. When quantitative, the CP is a number that is used to calculate the COP. For example, the mean time between failure (a possible CP) is used to calculate the operational availability (a possible COP). When qualitative, the CP provides essential information to be used to assess a COP. For example, statements from soldiers on ease of use could be used in the assessment of a COP which addresses the man to machine interface. The CP corresponds to the measure of performance (MOP) in the COEA. Definitions for the CP and MOP follow:

Third Level Performance Parameter Definition:{ORD, TEMP, APB}

CRITICAL PARAMETER (CP) -- A CP is a system specific quantitative or qualitative measure of physical performance or suitability. It is specified to support the assessment of a critical operational parameter (COP). It normally has a threshold and objective. The CP corresponds to the MOP in a COEA.

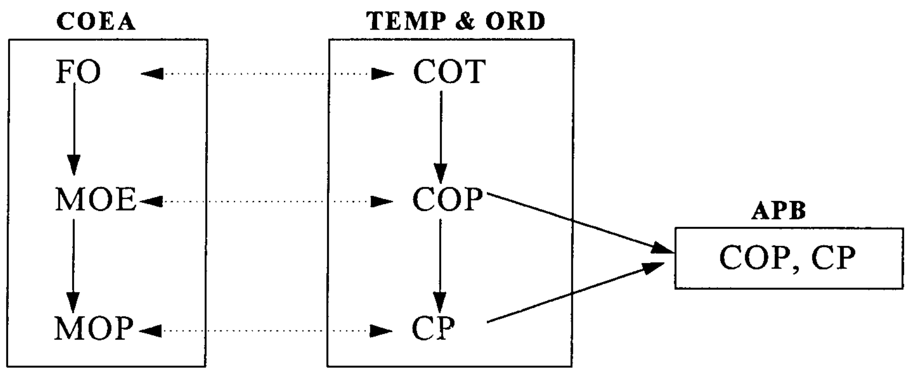
Third Level Performance Parameter Definition:{COEA }

Measure of performance (MOP) -- A MOP is a non-system specific quantitative measure of physical performance or suitability. It is specified to support the assessment of a measure of effectiveness (MOE) in the COEA. It normally has a threshold and objective. The MOP corresponds to the CP in the ORD, TEMP and APB.

The COTs, COPs, and CPs that are in the TEMP, ORD, and APB are now inherently linked to each other and to the FOs, MOEs and MOPs that are in the COEA. In the DoD 5000 series publications, all other performance parameter terminology should be purged. Milestone decision authorities (MDA) must refrain from adding performance parameters to the APB that are not approved COPs or CPs in the ORD and TEMP. Figure 9 depicts the new performance parameter terminology with inherent linkages. Solid lines denote the source for a lower tier parameter. The dotted line denotes a lateral tier linkage between a COEA parameter and a parameter used in the ORD and TEMP.

Figure 9 (New World)

BRAVE NEW WORLD



1. COT, COP & CP ARE SYSTEM SPECIFIC.
2. FO, MOE AND MOP APPLY TO ALL COEA ALTERNATIVES.

Key parameters in the APB are defined as stated below:

<u>New Definition:</u>

KEY PARAMETERS - Those critical operational parameters (COPs) and critical supporting parameters (CPs) that have thresholds that when not met, may require a reevaluation of alternative concepts and/or design approaches. Key parameters are listed in the acquisition program baseline. On an exception basis, the milestone decision authority may uniquely define a key parameter. When this happens, this parameter should be considered for inclusion as a COP or CP in the TEMP.

To accommodate the simplified performance terminology, we recommend the below revised ORD format for paragraph four.

Figure 10(ORD FORMAT)

ORD FORMAT

PARAGRAPH 4 (REQUIRED CAPABILITIES)

- COT 1
    - COP 1-1
        - CP 1-1-1
        - CP 1-1-2
        - etc..
    - COP1-2
        - CP 1-2-1
        - CP 1-2-2
        - etc..
- COT 2
    - COP 2-1
    - etc...

COT #

\# - # - # ← CP #

COP #

By now, some readers may have concluded that this all sounds nice, **<u>but</u>** our service or organization does not have the time, expertise or established staffing process to participate in the "Brave New World" of performance parameter establishment and linkage. ***<u>Unfortunately, the real world is less than ideal</u>***. The COEA is sometimes performed in a vacuum with little or no contact with the staffs and agencies that prepare the ORD, TEMP and APB. Some may argue that the very nature of the acquisition process makes the maintenance of consistent performance parameters among key documents prepared by various groups scattered over the United States- ***MISSION IMPOSSIBLE.*** The remainder of the article proposes a procedure to establish valid and consistent performance parameters among all the key acquisition documents.

Who is involved in the specification and linkage process? An integrated acquisition document development team (IADDT-see figure 11) should write and coordinate the required capabilities parts of the key acquisition documents for a proposed system. The team support costs in terms of personnel and TDY costs will be much less than the cost of proceeding into later acquisition phases with inconsistent and poorly specified key performance parameters. An engineering change proposal (ECP) resulting from a change in specified performance often results in significant costs. For major programs during phase three of the acquisition process, ECP costs are usually in the million dollars plus bill category!

Figure 11(IADDT-Team Composition)

POC from agency that prepares COEAs
Test project officer from OTA.
Test Manager from Program Management Office.
Test and Readiness POC from Program Executive Office..
Integrated Logistics Support representative from the Materiel Support Command.
System Engineer from likely matrix support agency or other appropriate source.
Test facility POCs from anticipated test ranges/facilities.
POC from PEO or designated agency responsible for drafting the APB.
User representative.

When does the performance parameter specification and linkage process happen? The "when" is answered by reviewing the phased acquisition process. {see figure one} The phased acquisition process coupled with the evolutionary requirements process complicates the performance parameter specification and linkage process. The process often lasts more than eight years and the evolutionary requirement process involves continual requirement/performance parameter refinement. Other people in other articles can describe how to shorten and simplify this process. The simplified performance parameter terminology and recommended process proposed in this article will work today and in the future world of acquisition reform. The integrated acquisition document development team (IADDT) should be formed upon approval of a mission need statement (MNS). The IADDT develops the functional objectives (FOs), measures of effectiveness (MOEs) and supporting measures of performance (MOPs) to be used in the COEA. Prior to milestone I, the IADDT drafts the ORD, the TEMP and APB for the most likely preferred concept (or concepts). All the key acquisition documents must be approved prior to or in conjunction with the milestone I Defense Acquisition Board (DAB). Whenever a FO, MOE, MOP, COT, COP, or CP is changed; the IADDT members must review all the key acquisition documents to ensure performance parameter linkages are maintained. At a minimum, the IADDT will review all key acquisition documents prior to a major test and prior to each milestone decision review. The IADDT reviews should be conducted to permit sufficient time to enact any needed changes prior to a major test or milestone review.

STEP 4: A "HOW TO" EXAMPLE

We have discussed the "what, who and when". Now for the fun part- the how. Using the simplified performance parameter terminology that is defined in step 3, we will outline the key steps in the specification and linkage process with a specific example. We will also suggest some tools to assist the integrated acquisition document development team (IADDT) in the accomplishment of their mission to consistently specify "truly critical" performance parameters among the key acquisition documents.

An approved mission need statement (MNS) normally starts the acquisition cycle. During phase 0, the four key acquisition documents are drafted in preparation for the milestone decision authority (MDA) to review for a milestone I decision. This is a critical period of time in the specification of performance parameters among the key documents. Decisions on required system performance that are made during phase 0 significantly impact the system design and life cycle costs. It is also the time of greatest uncertainty as to what the "truly critical" critical operational parameters (COPs) and critical parameters (CPs) may eventually be. In theory, the COEA is prepared for each approved MNS. The COEA provides the analysis to support the recommended system alternate. In practice, all the key acquisition documents are often prepared simultaneously. Considering the preliminary results from the COEA, the IADDT drafts the TEMP, ORD and APB for the likely most cost effective alternative. If the analysis does not clearly support a best alternative, it may be necessary to draft the key acquisition documents for several of the alternatives or even all of the alternatives.

We will use the combat net radio as an example system to demonstrate the performance specification and linkage process. For brevity sake, only one functional objective and its corresponding critical operational task will be fully developed in this example. Three system alternatives are proposed.

(1) Frequency hopping radio.
(2) Product improved AN/VRC-12 series.
(3) Improved high frequency radios.

1. Considering a mission area analysis, an approved mission need statement (MNS) starts the process:

MNS: Replace the aging AN/VRC-12 series combat net radios that are easily jammed, have poor supportability/maintainability, and low operational availability. When operating against the current and projected threat, the replacement system must provide reliable voice communications with adequate range to support command and control for forward deployed combat forces at division level and below. The

replacement system must also provide reliable data communications with adequate throughput and range to support battalion level and below digital targeting systems and command and control systems currently in a division. The replacement system must reduce operational and support costs and improve operational availability. The replacement system must be interoperable with other the services and equivalent level NATO ground forces.

2. Use the following numbering system for all FOs, MOEs, MOPs, COTs, COPs, and CPs.

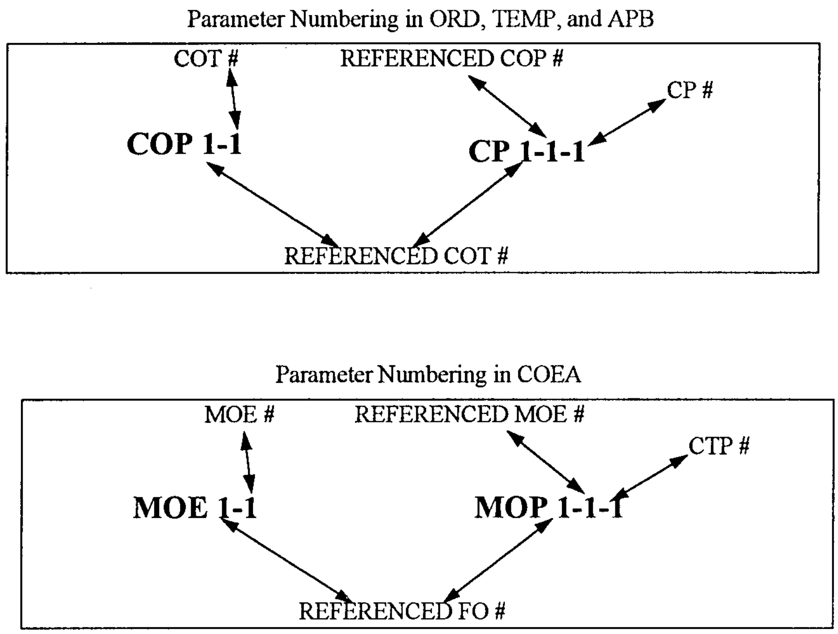


Figure 12 (Parameter Numbering)

3. Derive the COEA functional objectives (FOs) from the mission need statement.

MNS: Replace the aging AN/VRC-12 series combat net radios that are easily jammed, have poor supportability/maintainability, and low operational availability. When operating against the current and projected threat, the replacement system must **{FO 1}**<u>provide reliable voice communications with adequate range to support command and control for forward deployed combat forces at division level and below</u>.

The replacement system must also **{FO 2}**provide reliable data communications with adequate throughput and range to support battalion level and below digital targeting systems and command and control systems currently in a division. The replacement system must **{FO 3}**reduce operational and support costs and improve operational availability. The replacement system **{FO4}**must be interoperable with the other services and equivalent level NATO ground forces.

4. Specify the measures of effectiveness (MOEs) and supporting measures of performance (MOPs) for functional objective one.

{FO 1} provide reliable voice communications with adequate range to support command and control for forward deployed combat forces at division level and below.

MOE 1-1- Aggregate voice message completion rate (MCR) within a division with projected threat jamming.

MOP 1-1-1 : Voice MCR at 10,20,25,30,35 Kms with severe jamming.

MOP 1-1-2 : Voice MCR at 10,20,25,30,35 Kms with moderate jamming

MOP 1-1-3 : Voice MCR at 10,20,25,30,35 Kms with low jamming

MOP 1-1-4 : Voice MCR at 10,20,25,30,35 Kms with severe jamming and retransmission sites.

MOE 2- Voice message completion rate (MCR) within a division with jamming.

MOP 2-1 : Voice MCR at 10,20,25,30,35 Kms with no jamming.

MOP 2-2 : Voice MCR at 10,20,25,30,35 Kms with retransmission sites.

5. Assuming that preliminary analysis from the COEA indicates that the frequency hopping radio is the most likely cost effective system to meet the requirements specified in the mission need statement, specify the "truly critical" parameters to be used in the ORD, TEMP, and possibly the APB. {Only one COP with supporting COTs will be developed}. For this example, the specification of the COTs, COPs, and CPs is trivial. Functional objectives with supporting MOEs and MOPs translate directly into COTs with supporting COPs and CPs.

{COT 1} Provide reliable voice communications with adequate range to support command and control for forward deployed combat forces at division level and below.

COP 1- Aggregate voice message completion rate (MCR) within a division with projected threat jamming.

CP 1-1 : Voice MCR at 10,20,25,30,35 Kms with severe jamming.

CP 1-2 : Voice MCR at 10,20,25,30,35 Kms with moderate jamming

P 1-3 : Voice MCR at 10,20,25,30,35 Kms with low jamming

CP 1-4 : Voice MCR at 10,20,25,30,35 Kms with severe jamming and retransmission sites.

COP 2- Voice message completion rate (MCR) within a division with jamming.

CP 2-1 : Voice MCR at 10,20,25,30,35 Kms with no jamming.

CP 2-2 : Voice MCR at 10,20,25,30,35 Kms with retransmission sites.

NOTE: It is not always this easy. When system alternatives are not similar, the COEA parameters must be more generic in nature to apply to all alternatives. For example, two alternatives to kill SCUDS could be surface to air missiles and air to air launched missiles. An appropriate measure of effectiveness (MOE) might be the time required to bring the system into a fully operational status upon deployment into the theater to be protected from SCUD attack. For these two alternatives, an inappropriate MOE would be the time required to move and erect a ground missile launcher. This MOE is only applicable to one alternative. For the surface to air missile alternate, the IADDT might specify the time required to move and erect a ground missile launcher to be a COP. This COP would then be linked in a parameter correlation matrix to the COEA MOE that specifies the time required to bring the system into a fully operational status upon deployment into the theater to be protected from SCUD attack.

6. Specify the key parameters to be used in the APB. COPs and supporting CPs are candidates for the key parameters. The APB is a top level management document with and the list of key parameters should remain small. A general rule is to list all the COPs and few, if any, CPs. All COPs and CPs are "truly critical" but they all do not necessarily meet the requirement that a failed threshold necessitates a reevaluation of alternative concepts or design approaches. The IADDT must evaluate all the COPs and CPs to determine which ones meet the requirements associated with a key parameter in the APB. Only list those CPs that are known to have high technical risk and clearly dominate the threshold of the supported COP. For our combat net radio example, only COPs would be listed as key parameters in the APB.

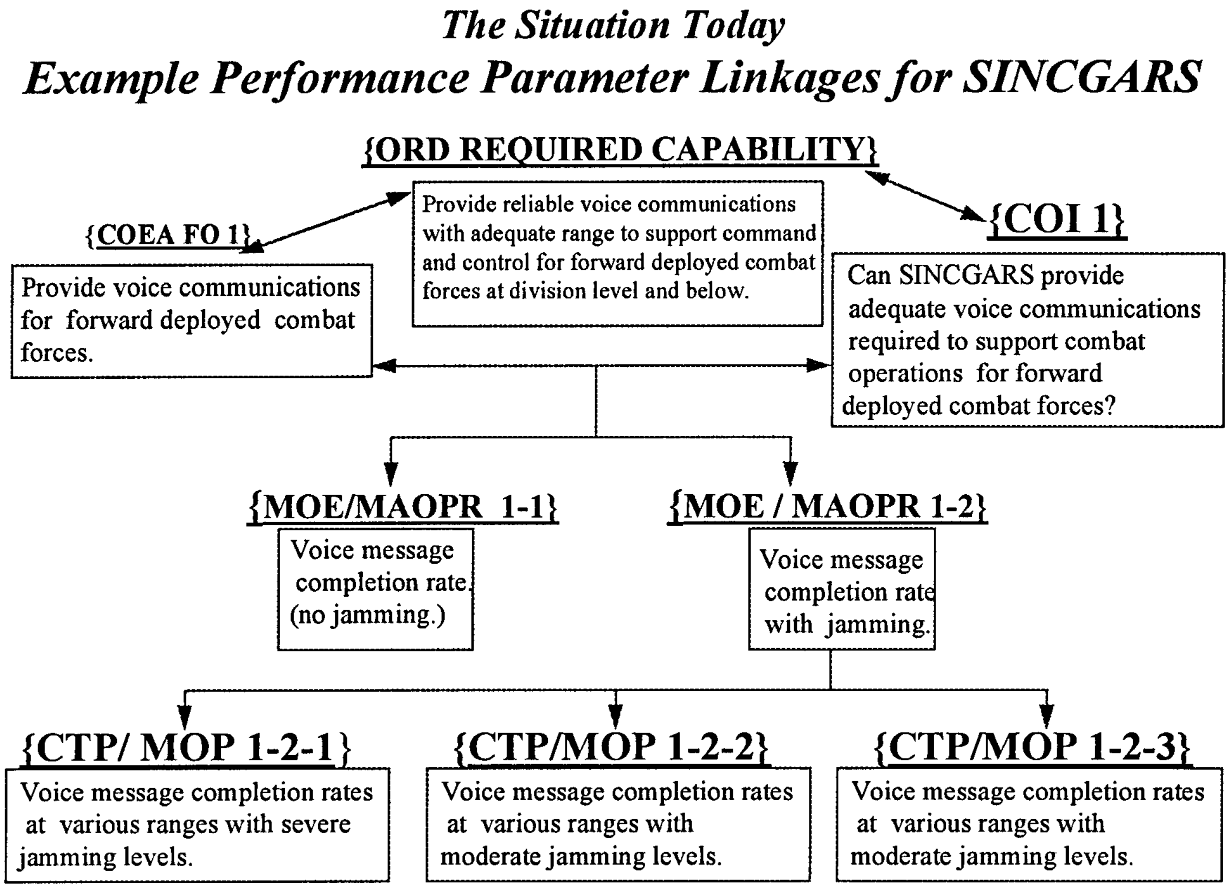
7. The IADDT should use a parameter correlation matrix as tool to ensure that parameters are consistent among the ORD, TEMP and APB. This tool also established linkage to the COEA. The matrix also shows what testing is planned or has been executed to demonstrate system performance for each parameter. An enclosure to the matrix will list all the parameter statements with thresholds and objectives. This enclosure will also provide test location and test POCs. An example parameter correlation matrix follows: (See figure 13)

Figure 13 (Sample Parameter Correlation Matrix}

FO #	COT #	MOE #	COP #	MOP #	CP #	TEST/DATE
1	1					DT 4/3QFYXX IOTE/4QFYXX
		1-1	1-1			DT 4/3Q-FYXX IOTE/4QFYXX
				1-1-1	1-1-1	DT 4/3QFYXX IOTE/4QFYXX
				1-1-2	1-1-2	DT 4/3QFYXX IOTE/4QFYXX
				1-1-3	1-1-3	DT 4/3Q-FYXX IOTE/4QFYXX
				1-1-4	1-1-4	DT 4/3Q-FYXX IOTE/4QFYXX
2	2					DT5/2Q-FYXX IOTE/4QFYXX
		2-1	2-1			DT5/2Q-FYXX IOTE/4QFYXX
				2-1-1	2-1-1	DT5/2Q-FYXX IOTE/4QFYXX
				2-1-2	2-2-2	DT5/2Q-FYXX IOTE/4QFYXX

As a final example, we will demonstrate that there is no need to wait for the "Brave New World" to be officially implemented. Most of the recommended procedures can be implemented now and remain within DoD 5000 series guidelines. Applying the present terminology with the proposed numbering system, we will depict one COI with supporting/linked parameters for the preceding combat net radio example. We will specify and link (as much as possible) the recommended simplified terminology and procedures to be hopefully approved in the future.

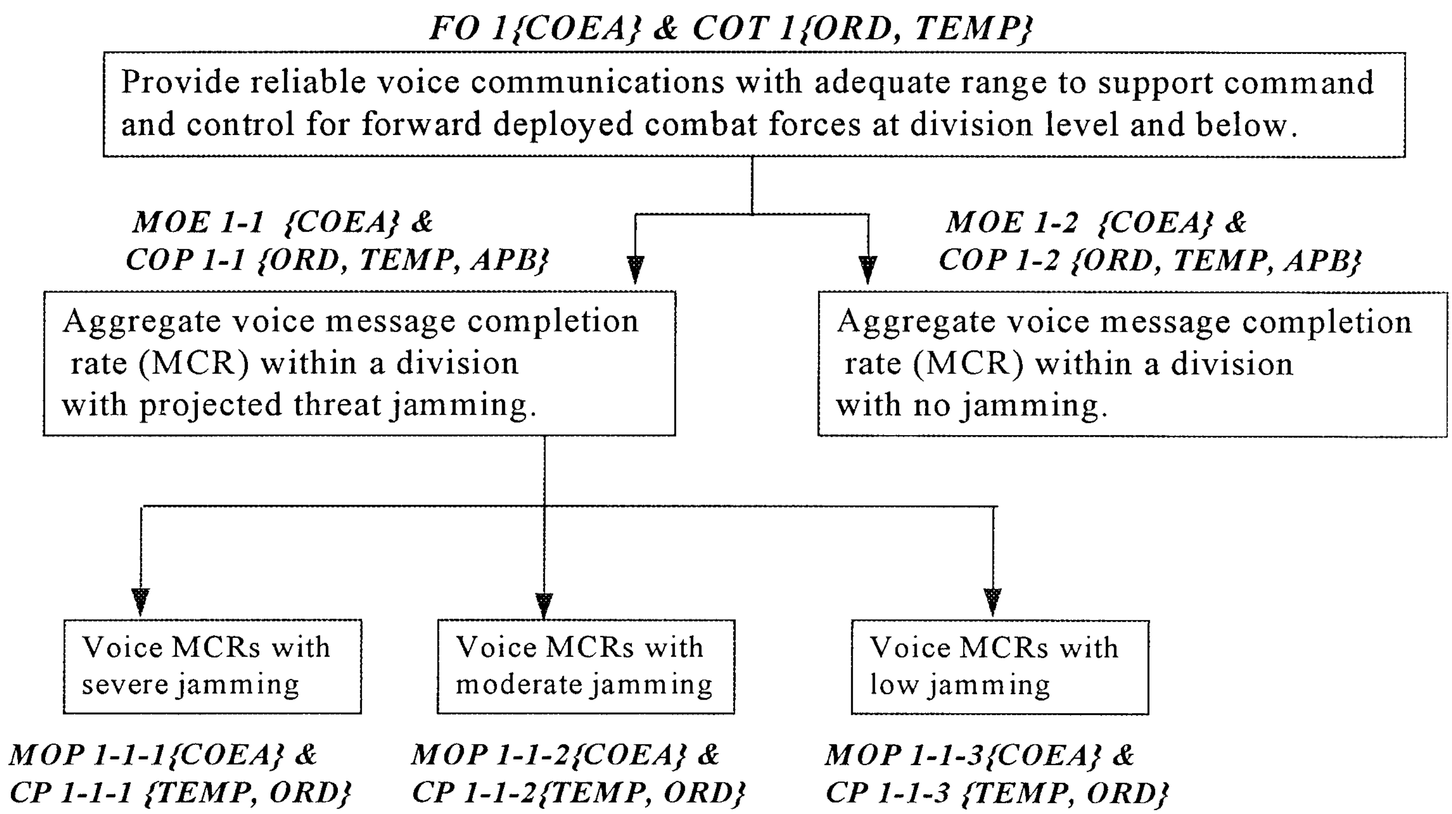
Figure 14 (The Situation Today with Recommended Procedures)



Now we will repeat the process using the recommended simplified terminology with inherent linkages.

Figure 15 (The Future with Recommended Procedures & Simplified Terminology)

The "Brave New World" -The Future
Example Performance Parameter Linkages for SINCGAR



IN CONCLUSION

We have discussed how to specify performance parameters and establish linkages using the present performance terminology. This process is challenging but possible when implemented by an integrated acquisition document development team (IADDT). The two preceding examples illustrate that the "Brave New World" can be partially implemented today and still remain within the DoD 5000 series guidelines. Why wait? Consistently specified "truly critical" parameters among the key acquisition documents are the foundation upon which a major defense acquisition program is built. Without this foundation, the program will fail or, even worse, produce a weapon system that is fielded and does not meet the user's requirements.

ENDNOTE (Current DoD 5000 Series Definitions)

1

1. **CRITICAL OPERATIONAL ISSUE** (COI) -- A key operational effectiveness or operational suitability issue that must be examined in operational test and evaluation to determine the system's capability to perform its mission. A critical operational issue is normally phrased as a question to be answered in evaluating a system's operational effectiveness and/or operational suitability. {DoDI 5000.2, Part 15}

2. **CRITICAL SYSTEM CHARACTERISTIC** (CSC):

   a. Critical system characteristics are those design features that determine how well the proposed concept or system will function in its intended operational environment. CSCs include survivability; transportability; energy efficiency; and interoperability, standardization, and compatibility with other forces and systems including support infrastructure. {DoDI 5000.2, Part 4}

   b. Critical system characteristics will address electronics counter-countermeasures (ECCM) and Wartime Reserve Modes (WARM) requirements; conventional, initial nuclear weapons effects, and nuclear, biological, and chemical contamination (NBC) survivability; natural environmental factors (such as climatic, terrain, and oceanographic factors); and electromagnetic compatibility and frequency spectrum assignment for systems operating in the electromagnetic spectrum. Define the expected mission capability (i.e., full, percentage degraded, etc.) in the various environments. Include applicable safety parameters such as those related to system, nuclear, explosive, and flight safety. Identify communications, information, and physical and operational security needs. {DoD 5000.2M, Part 3-1}

3. **CRITICAL TECHNICAL PARAMETERS** (CTP)- CTPs are derived from the Operational Requirements Document, critical system characteristics (see Part 4 of DoD Instruction 5000.2, "Defense Acquisition Management Policies and Procedures"(reference (b)) and technical performance measures (see Section 6-A of DoD Instruction 5000.2, "Defense Acquisition Management Policies and Procedures" (reference (b)) and should include the parameters in the acquisition program baseline (see Part 14 of DoD 50002.M). Discuss the relationship between the critical technical parameters and the minimum acceptable operational performance requirements in the Operational Requirements Document. {DoD 5000.2M, Part 7}

4. **FUNCTIONAL OBJECTIVES (FOs)** -- FOs are statements describing, in quantitative terms, the tasks a system will be expected to perform. They depend upon the type of system at issue. For example, when analyzing transportation systems, the objectives are stated in terms of movement requirements; for firepower systems, they reflect the types of targets to be engaged. The effectiveness of system alternatives is

then measured in terms of the degree to which the functional objectives would be attained.{DoD 5000.2M, Part 8}

5. **KEY PARAMETERS** - Those parameters that if the thresholds are not met, the milestone decision authority would require a reevaluation of alternative concepts or design approaches. {DoDI 5000.2, Part 11-A}

6. **MEASURE OF EFFECTIVENESS** (MOE) -- MOEs are tools that assist in discriminating among a number of alternatives. They show how alternatives compare in meeting functional objectives and mission needs. [i] Measures of effectiveness should be developed to a level of specificity such that a system's effectiveness during developmental and operational testing can be assessed with the same effectiveness criteria as used in the COEA. {DoD 5000.2M, Part 8}

7. **MEASURE OF PERFORMANCE** (MOP) - MOPs are not specifically defined by DoD instruction or manual; however, a commonly accepted definition follows: MOP is defined as a quantitative measure of the lowest level of physical performance (e.g. range, velocity, throughput) or physical characteristic (e.g., height, weight, volume, frequency) of a system. MOPs are derived from MOEs. {AFMAN 10-603}

8. **MINIMUM ACCEPTABLE OPERATION PERFORMANCE REQUIREMENTS (MAOPRs)** - A summary of the critical operational effectiveness and suitability parameters and constraints (manpower, personnel, training, software, computer resources, transportation, and etc.) described in the Operational Requirements Document (ORD). {DoD 5000.2M, Part 7}

9. **OBJECTIVE**- A measurable, beneficial increase in capability or operations support above the threshold. {DoD 5000.2M, Part 3-1}

10. **PARAMETER** - A determining factor or characteristic. Usually related to performance in developing a system. {Commonly accepted definition-Not specifically defined in DoD 5000 series}

11. **PERFORMANCE**- Those operational and support characteristics of the system that allow it to perform effectively and efficiently its assigned mission over time. {DoDI 5000.2, Part 15}

12. **REQUIREMENT**- Is a mission need. Requirements are initially stated in broad operational terms and are progressively refined in both number and specificity during each acquisition phase.{DoDD 5000.1, Part 2}

13. **TECHNICAL PERFORMANCE MEASURES (TPM)** -- Performance measures that are developed and maintained throughout the process. These measures will be used to assess how well the evolving design meets the system requirements. {DoDI 5000.2, Part 6-A}

14. **THRESHOLD** - The minimum acceptable value required to satisfy the mission need.{DoDI 5000.2, Part 4-B}

MANAGING FLIGHT TEST PROGRAMS: An Earned Value Approach

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ABSTRACT

Traditional measures of flight test progress, such as, counting flight hours or completed test points, are limited in deciding resource allocation and prioritizing test activity. A systems engineering approach was utilized to improve the planning, controlling, and status reporting of the flight test program. Earned value, in terms of test-point hours, provides a normalized measure of work effort (test activity). This concept was derived from the DOD Cost/Schedule Control System Criteria and employed with success in a large aircraft developmental flight test program.

INTRODUCTION

You can't control what you can't measure. [1]

—Tom DeMarco

Among the many challenges encountered in the management of major weapon system acquisition programs is the balance between system cost, system schedule, and system effectiveness.[2] A good project manager must consistently be able to focus the "right resources" on the "right problem" at the "right time" to obtain acceptable results. Each phase of defense acquisition presents the program manager with the challenge of integrating and coordinating a set of work processes while controlling the risk to cost, schedule, and effectiveness. Large, high visibility defense acquisition programs present unique challenges. The "high visibility" creates an abundance of scrutiny and oversight. The "large" means more resources, more complex work processes, and therefore, more risk.[3]

Flight testing air vehicles is one of the work processes found in aircraft acquisition programs and is accompanied by similar challenges in controlling cost, schedule, and effectiveness. In large, high visibility aircraft development programs, the flight test project can become a program within a program. The test manager's task is to convert test resources into output using test processes to achieve a program objective.[4]

Traditionally, the flight test community has focused on the technical aspects of flight test (planning the test, conducting the test, and reporting the results) and had a weak commitment to the problems of the program office in terms of cost and schedule. "That's the SPO's problem!"[5] The tester saw the priority as delivering the most capability to the user and identifying system deficiencies, regardless of the impact of this activity on cost and schedule. Consequently, the program manager was often surprised by problems encountered in flight test, then was left alone to recover within program cost and schedule constraints. Overruns in flight test commonly led to overruns in program cost and schedule or delivery of less capability to the user.[6]

The situation has changed. Cutbacks in defense programs and test budgets, previous failures in acquisition programs, and the increase oversight of DOD and Congress require greater efficiency and better program management. To improve the weapon system acquisition process, Air Force

Material Command (AFMC) introduced a variety of programs, such as, Integrated Product Development, Integrated Weapon System Management, and Single Face to the Customer. In addition, the Acquisition Professional Development Program and a professional acquisition corps will result in more effective and efficient management.[7]

The incorporation of quality concepts and the introduction of integrated product teams[8] mean testers and program managers must become better partners for the success of the program. Test managers who may believe that flight test is "unmanageable" must now assume a stake in the responsibility of program management.

Are large flight test programs *manageable*? Despite their scientific approach and technical competence, flight testers often lack the knowledge of or training in program management tools to control cost and schedule. Large programs *are* manageable but traditional test management tools are inadequate.

The purpose of this paper is to describe a successful innovation in the risk management of a large developmental flight test program. By following a systems approach and modifying several program management tools and methods, the quality of the test process was significantly improved. This change was introduced almost four years ago and substantially enhanced the planning, controlling, and progress reporting of the major weapon system program.[9]

BACKGROUND

Thing's could be worse.

—Princess Leia Organa

They're worse! [10]

—Han Solo

Several reasons demand concern for improving the management of large flight test programs. First, overruns in cost and schedule are typical for defense acquisition programs. A look at 24 defense acquisition programs showed an average cost overrun of 45 percent and a schedule overrun of 65 percent in the Engineering and Manufacturing Development phase of the programs.[11] Second, flight testing is an expensive process. The government cost for flight test of a large aircraft development program can average $750,000 to $1 million each week.[12] Next, the new acquisition directives and regulations that resulted from DOD acquisition reform, most notably the DODD 5000 and the AF Instruction 99 series, require a more disciplined approach to the conduct of program acquisition and flight test project management. Finally, the quality movement and the emphasis on quality practices within AFMC, have motivated an endless drive for continuous improvement of all acquisition processes.

The spiraling cost of aircraft weapons in an environment of decreasing defense budgets and the need to be "leaner and meaner," means that time spent in flight test must be leveraged to maximize the return on every acquisition dollar spent in obtaining capability for the user, efficiently, and within schedule. Appreciating the need for an improved flight test management system requires a look at the challenges of program management, the competing nature between program management and flight test, and the test process.

Project Model

Both program acquisition and its subset, the flight test program, can be viewed in terms of the simple model depicted in Figure 1. Both processes involve converting resources into output using work processes. The output satisfies an objective expressed as

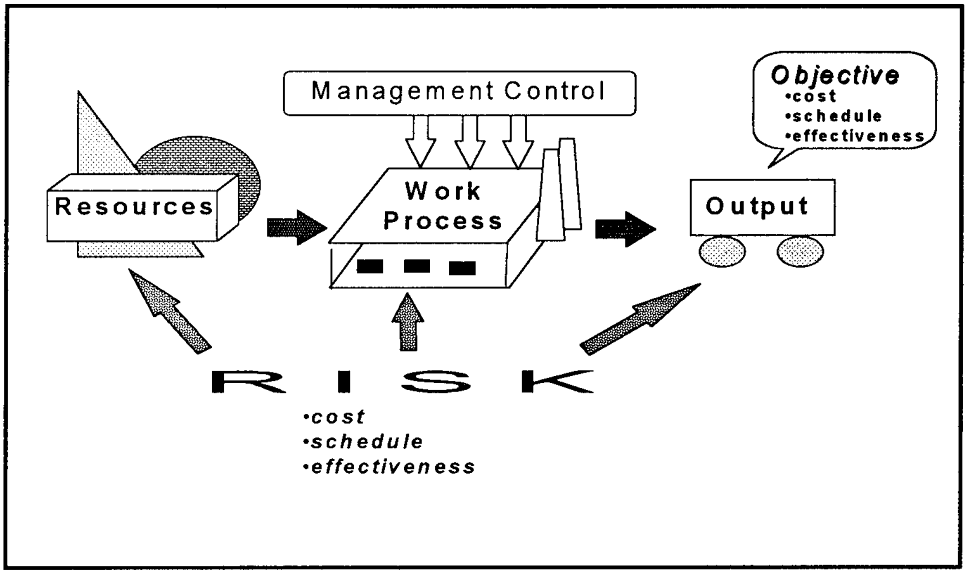

Figure 1: Acquisition Project Model

meeting some standard or expectation in terms of cost, schedule, and effectiveness. Generally, the user or customer specifies the objective. Unknowns will exhibit themselves as risk to cost, schedule, and effectiveness. Risk is the probability of an undesirable event occurring *and* the impact of the event on project cost, schedule, and effectiveness. Minimizing risk decreases the "probability" of the event or its "impact." Risk is minimized using a set of management tools to control the work processes.[13]

Flight test work processes, such as, test planning, technical and safety reviews, engineering, configuration control, and data analysis, are used by the flight test manager to produce output in the form of test data results. Technical risk is inherent due to design problems, failure of hardware or software, and other deficiencies discovered during testing that decrease system effectiveness. Management risk results from making decisions to deal with technical problems and taking actions to meet cost and schedule constraints. Risk encountered in flight test can cause slips in the program acquisition schedule and additional cost.

Testing in Systems Acquisition

A test is a disciplined process that follows the scientific method of objective, hypothesis, experiment, data collection, analysis, and results. By definition a test must be repeatable, otherwise it is not a valid test. The same initial conditions and the same test procedures, will result in the same conclusions. Tests validate technical specifications and identify capabilities, limitations, and deficiencies. The purpose of testing as part of systems acquisition is to (1) provide timely, accurate, and affordable information to the program manager for assessing military utility and cost effectiveness; (2) reduce risks associated with acquisition; and, (3) ensure the acquisition community is delivering operationally effective and suitable systems to the Air Force. The end result of testing is the delivery of weapon system capability and the fulfillment of a specific objective.[14]

The "fly-fix-fly" test methodology prevalent during the last decade led to a short-term management view in flight test, concentrating on the immediate problem and losing sight of the bigger picture. To correct

this deficiency, the test process was redefined. AFI 99-103 replaced the short-term viewpoint of "fly-fix-fly" with a discipline scientific approach of the "predict-test-compare" methodology. It is the goal of this process to produce effective and suitable systems that satisfy the user's needs by reducing the risk to cost, schedule, or effectiveness.[15]

The objectives of a flight test program are specified in a test plan. The test team prepares this document which details the specific questions that will be answered (objectives); the anticipated or required performance (hypothesis); the test conditions and procedures used to acquire the data (experiment); and, the data required and the evaluation technique (analysis). The time spent in flight (flight hours) becomes the resource that must be prudently managed, as this is the only opportunity data can be collected to fulfill the requirements of the test plan. In effect, the flight test manager's task is to efficiently and to effectively transform flight test hours into time "on test condition," which is the time spent collecting data.

The changes to a more disciplined test process demand the tester take more responsibility to complete testing utilizing the resources and within the schedule specified. If this is not possible, the program manager must be informed of a potential breach in the baseline in sufficient time to minimize impact on program.

Flight Test Dilemma

The challenge for both the program and test managers is to identify and minimize all potential risks to effectiveness within a specified budget and schedule. The three factors–cost, schedule, and effectiveness–are interdependent. In the event of unanticipated problems, delivery of specified effectiveness will increase cost and schedule. If either cost or schedule is constrained, then the equilibrium may only be regained by a sacrifice in effectiveness. The typical experience in acquisition finds continual pressure against cost and schedule to deliver the required effectiveness.

For the program manager trying to keep cost and schedule under control, the testing activity can only bring bad news. If everything goes right, then there is no impact to cost and schedule. But this rarely happens. Most likely problems will be discovered, delays will result, and both cost and schedule will increase. This presents the tester with a competing set of commitments: the first to the program manager to reduce risks and make schedule; the second, to the user to provide fully tested equipment with the desired capability. Satisfying both of these commitments becomes the flight test dilemma.

Projects fall behind for several reasons: poor estimates of the work effort, lack of understanding of requirements, inadequate risk assessment or unanticipated problems (unknown-unknowns). Projects can also get into trouble through poor management practices: pressure to deliver, poor monitoring of progress, confusing effort with progress, or adding more resources to a project already behind. Although little can be done about unknown problems, the greatest leverage against cost, schedule, and effectiveness risks is found in good management actions. This requires a visionary view over the entire course of the flight test program; appreciating the context of the acquisition program and its milestones; and, adopting a risk management approach.

Nature of the Problem

There are three aspects to the long range management challenge of flight testing: planning, controlling, and reporting progress.

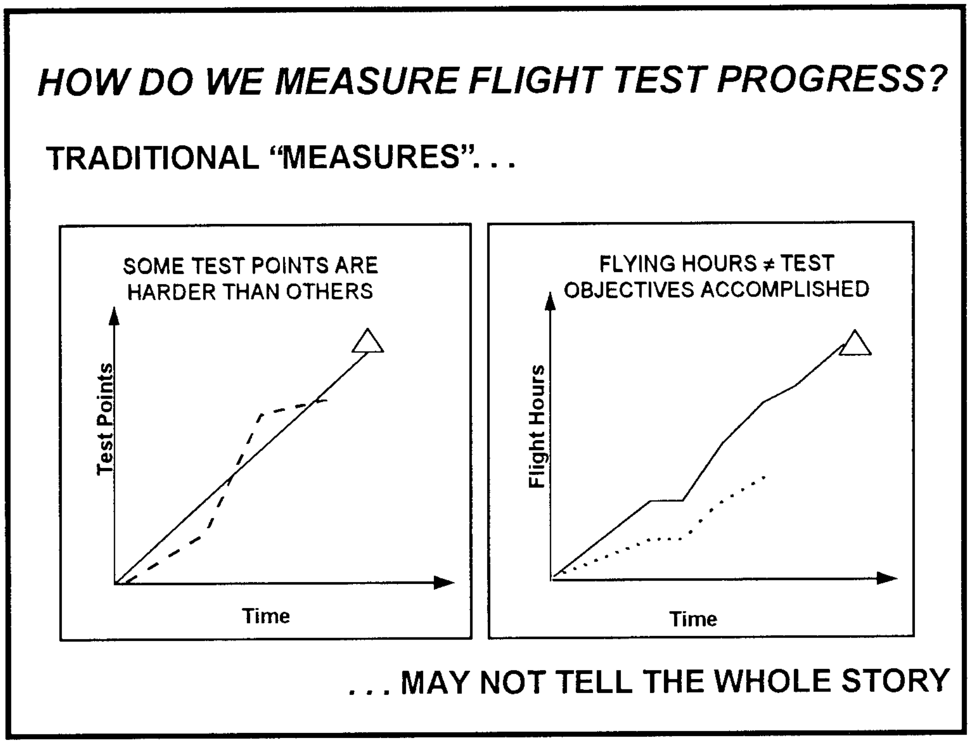

Figure 2: Traditional Measures of Flight Test Progress

Each area needs management attention to control risk during the flight test process.

Detailed long-range *planning* of complex programs is labor intensive and time consuming. The inherent uncertainty of development programs complicates a logical approach. Previously, flight test planning was limited to test objectives, test procedures, test conduct, and technical and safety concerns.[16] Today, program concerns are equally important. The program manager will ask specific questions of the tester: Is there enough time to satisfy all obligations? How long will a specific test take? When will a modification be delivered and what are the prerequisites required? In addition, every decision in a complex program will come with both liabilities and benefits. Choosing the right alternative at a decision point requires the knowledge of its impact on cost and schedule. Long-range, end-to-end planning and the integration of test activity are now possible due to powerful personal computers and project manager software. Long-range program planning, properly performed, is invaluable in helping with decision making and providing answers.

During execution, *controlling* the course of the test project toward the objectives will depend on reliable, accurate information and the ability to assess the impact of an event on the project's future. Good estimates and a detailed plan will help in decision making if the planning tool can provide timely forecasts and results. Typical questions will include: What is the impact of a failure—the incorrect design of a system or the loss of an airplane—on the schedule? What is the effect of cutting 3 months out of the schedule or adding $10 million dollars to the project? Is there enough time to complete all requirements at the current flight rate? Smart control requires accurate forecast based on quantifiable and defendable work process metrics.

Likewise, *reporting* status of large, high visibility programs is not straightforward. These programs are characterized by complex systems, long duration, and a large test matrix. Outsiders, often program managers without an appreciation for the detail, want a simple answer to the simple question: Are we on schedule? Of course, this question spawns an entire set of follow-on queries: Will we finish on time? What is the impact of this problem on schedule? Can the schedule be made up? What will additional resources provide in schedule? Congress is even less tolerant—How much testing is complete? Providing a straight forward answer of "63%" may communicate an incorrect conclusion: Has 63% of effort, or 63% of funds, or 63% of schedule been expended? Each is a different viewpoint.

Traditional methods of measuring progress in the flight test program include counting (1) completed test points, (2) flight hours flown, (3) objectives completed, or (4) a combination of these measures. For example, if a program contains 1000 test points and 400 have been completed, then the answer, "40% of the test points are complete" might be interpreted as "the program is 40% complete." Likewise, a 100-flight-hour program with 30 hours flown may be 30% complete rather than "30% of the flight hours have been expended"; or, 5 of 8 objectives are completed and consequently "62% complete". Each measure suffers from the same shortcoming. They convey only information regarding the specific measures—test points, flight hours, or objectives—but are often erroneously taken as an indication of the work performed. Although useful to show the status of a resource, they are incomplete in predicting future status, progress, or work completed. Ideally what is needed is one measure that could normalize the work by equating effort, cost, and schedule.

These three aspects of project management–planning, controlling, and reporting–are not unique to the effort of flight test as each is found in every project management situation. Unfortunately, a community founded in the scientific method more often resorts to insufficient management planning practices rather than a disciplined, systems analysis approach of "planning the work and working the plan" using metrics and meaningful measures of progress.

The Requirements for Improvement

Given a perspective of the purpose of testing, the flight test dilemma, and the inherent problems of traditional approaches to flight test management, the requirements of a risk management system to counter the shortfalls caused by the problems identified can be stated. Specifically, the system should:

- assist in planning, controlling, and reporting of the flight test project;
- measure progress towards individual test objectives and program milestones;
- provide an insight into flight hour requirements to meet major test program milestones;
- measure and track the use of flight test resources; and,
- identify critical paths, resource availability/constraints, test force capacity, and program milestones.

To meet these conditions, the solution had to fulfill additional needs. To assist in planning and integrate test activities, prerequisites, milestones, and resources, use of PC–based project management software is required. The software should accommodate the specification of exit criteria; the identification

of critical paths, critical resources, or duplication of effort; and, support flight test and mission planning. For the control function, the system should be capable of accepting changes in the plan, along with providing a means of assessing impact from "unknown-unknowns," changing requirements, or "what-if" type questions in a timely manner. Finally, the system should be able to track and report progress using a normalized measure of work, support test personnel and project decision makers, and produce reports for use by senior program management officials to understand or convey progress of the test program.

A NEW PARADIGM

Do not follow where the path may lead. Go instead where there is no path and leave a trail. [17]

—Anonymous

Development of a risk management process followed a system analysis approach. The concept adopted was based on systems engineering and the contract management tool used by DOD.[18] To measure the work effort, an earned value basis was used which allows for realistic cost and schedule assessment. The development process consisted of 5 steps as shown in Table 1.

Step 1: Identify Requirements

Three types of requirements influence flight test management: test requirements, program milestones, and resources required. Test requirements evolve from user operational needs, contractual specifications, and exit criteria for milestone decisions. The user's operational needs are translated into technical requirements. Specifications are the technical requirements for which the manufacturer is contractually committed. Technical requirements that are quantifiable and testable become test requirements. Completion of a test requirement requires a specific set of tests to be performed. Data

Table 1: System Engineering Approach to Managing Flight Tests

	Step	Outcome
1	**Identify requirements**	• **Test requirements** • **Program milestone** • **Resources required**
2	**Define the work**	• **Estimate of work required to accomplish each test requirement** • **Work sequence (network)** • **Work packages**
3	**Schedule the work**	• **Work path constrained by milestone and resources** • **Time-phased work plan**
4	**Baseline the work**	• **Budget at completion** • **Schedule of work effort over time** • **Commitment to plan**
5	**Execute the plan**	• **Metrics to monitor performance against plan** • **Adjustments to plan**

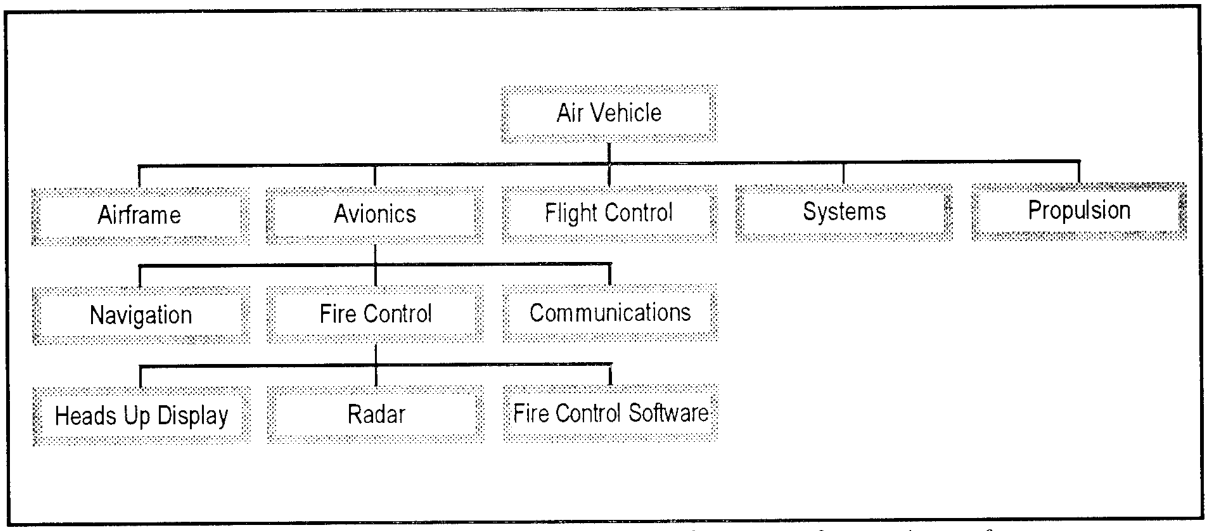

Figure 3: Product Work Breakdown Structure for an Aircraft

obtained from these tests are used to show achievement or failure of the test requirement. The outcome of this step is achieved when the test to accomplish each requirement is identified and prioritized.

Program milestones are identified in program documents, such as, Acquisition Program Baseline, Program Management Directive, Test and Evaluation Master Plan, or a master schedule.[19] These are program commitments that the test program must support. Examples include production decisions, interim reports, end of testing, and reports to Congress. All major program milestones affected by test activity must be identified in this step.

Finally, the availability of resources necessary to accomplish testing must be determined. This includes the delivery and configuration of test articles, special test assets or facilities, and personnel. Requirements' identification will be a continuous process as changes will occur during the conduct of testing. All changes or added requirements must be critically evaluated prior to incorporation in the schedule and commitment of resources.

Step 2: Define the Work

Test requirements specify the work that must be performed. This step quantifies the work and charts the work path. The specific test work is described in the test plan. Test plans translate requirements into test points. Test plans are normally functionally oriented by engineering discipline or aircraft system. The test plan contains a test objective, the initial conditions of the test, the procedure to be followed, and the data needed to satisfy the test objective. Large development flight test programs can have dozens of test plans, therefore, a Work Breakdown Structure (WBS) is used to breakdown and organize this effort.

The WBS is a system engineering tool that organizes and defines the work to be performed in functional oriented or product oriented categories.[20] The WBS is used to break complex systems into subsystem and component levels. An example WBS for an airplane and expanded along the avionics system is shown in Figure 3. The complete WBS would expand each box down to a component level. At this level or tier, the work effort required to produce the

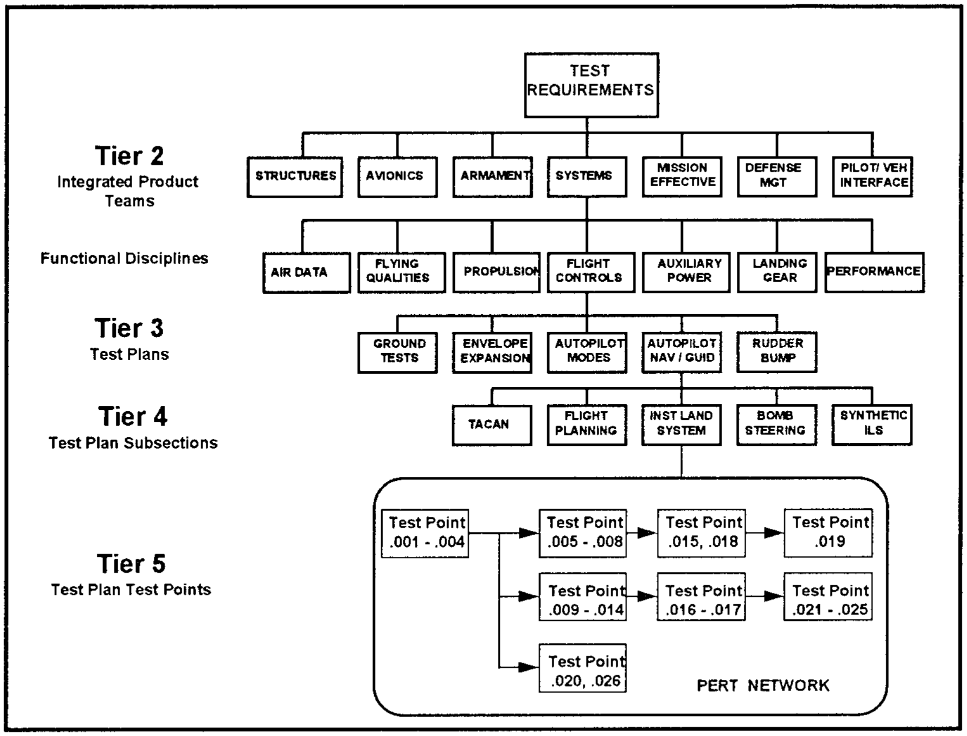

Figure 4: WBS for Flight Test Program

component can be specifically defined and is called a *work package*. By summing up each tier, the work effort required to produce any sub-system or the total aircraft can be obtained.

A function oriented WBS is used to organize all the test work by engineering discipline down to the work package level. A flight test work package is a functional breakdown of test points, that are similar in procedure and configuration. Each work package contains specific test points identified by a unique number and the expected cost of completing this work. The expected or budgeted cost of work is measured in *test-point hours*.

A *flight hour* is broken into test-point hours and overhead. Overhead is a fact-of-life cost of operation. It includes takeoff, cruise to the test range, air refueling (to extend flight time), configuration changes, repeated test points, problems with the aircraft or instrumentation, and landing. Normally, during these activities no productive testing or work is accomplished. The test-point hour is the time spent acquiring data for a test, the "on-condition" time. The overall cost of flight testing is measured in *flight hours* and work complete is measured by *test-point hours*. The ratio between the two, the efficiency of converting flight hours into test-point hours, is called the *flight test efficiency.* The composition of a flight hour and overhead is shown in Figure 5. The use of test-point hours allowed each point to be normalized, thus allowing a direct work effort comparison between every test point.

Finally, the tests required to achieve each test objective is defined. The path through the test plans is specified and the sequence of testing is defined. These paths are assembled into a network representing the complete test effort. Figure 4 shows an example PERT network[21] of activity. Boxes identify test points or work to be accomplished and rounded boxes are test requirements:

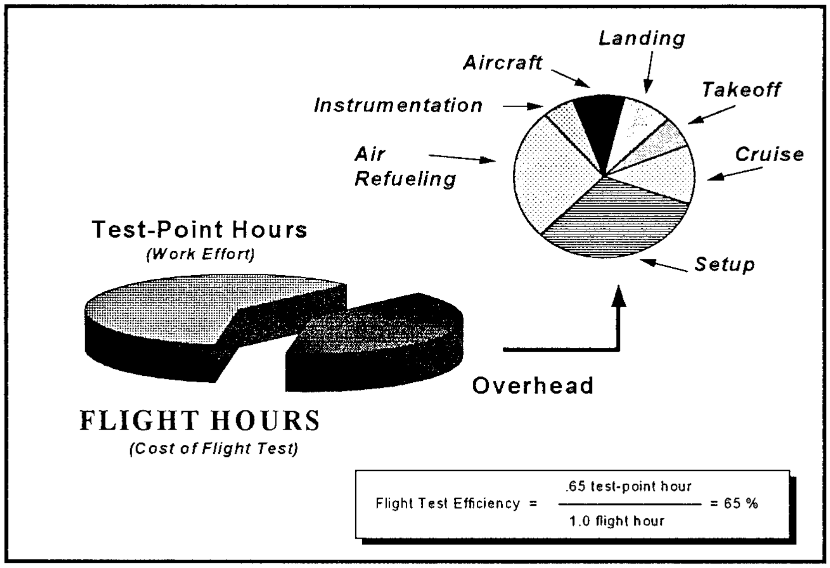

Figure 5: Anatomy of a Flight Test Hour

program milestones, test objectives, or constraints. This is a very labor intense part of the process. Each functional discipline must be integrated into the network. Undefined test activity or work must be accounted for with best estimates until further detail is available.

Step 3: Schedule the Work

In this step, the output of Step 2, the work activity network, is constrained by test milestones and available resources. The PERT network is transformed into a

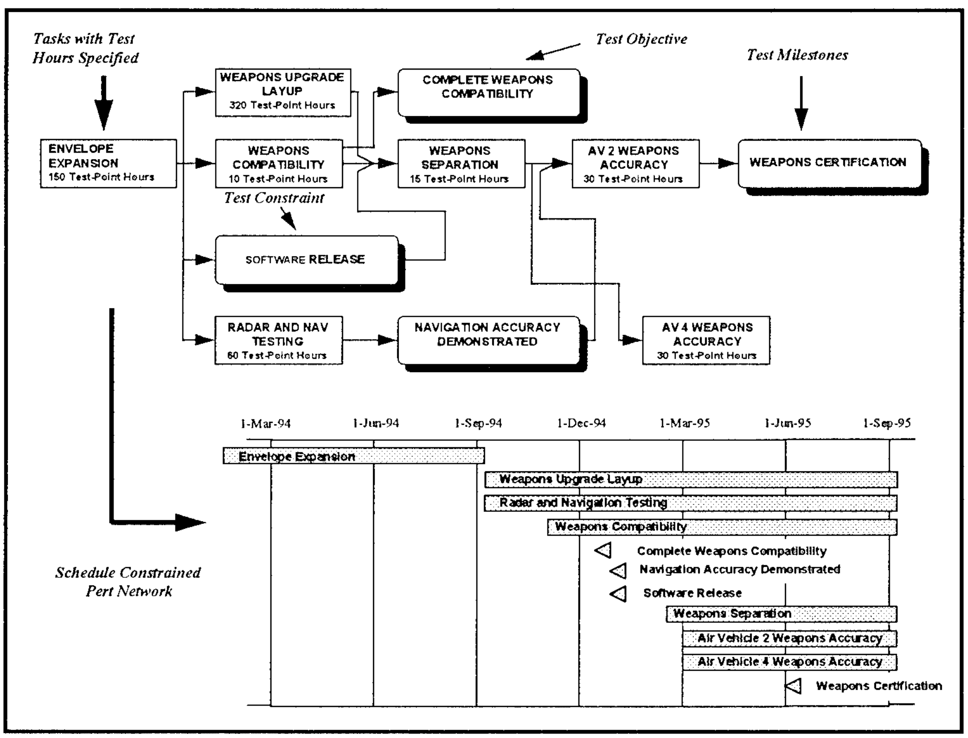

Figure 6: Defining and Scheduling the Work

schedule by adding dates. The outcome of this step is a time-phased plan that specifies the work effort within a defined schedule, as shown in Figure 6.

The anticipated fly rate will determine the capacity to expend flight test hours. The availability of the aircraft and associated test support resources will determine how often it can fly and what fly rate (flight hours/month) can be obtained. Using flight test efficiency and converting flight hours into test-point hours, the amount of schedule required to accomplish the entire test program can be estimated. Constraints will create "critical paths" through the network. Shortfalls are identified and management action can be taken to alleviate the scheduling pressure. The outcome of this step should be a schedule that management can support.

Step 4: Baseline the Work

Once a schedule constrained plan is defined, the time-phased accomplishment of work can be determined. This involves the summation of each flight test work package as a function of time. The result is a "baseline" that equates work effort over calendar time. The baseline is an invaluable tool as it will be used during execution of the test program to

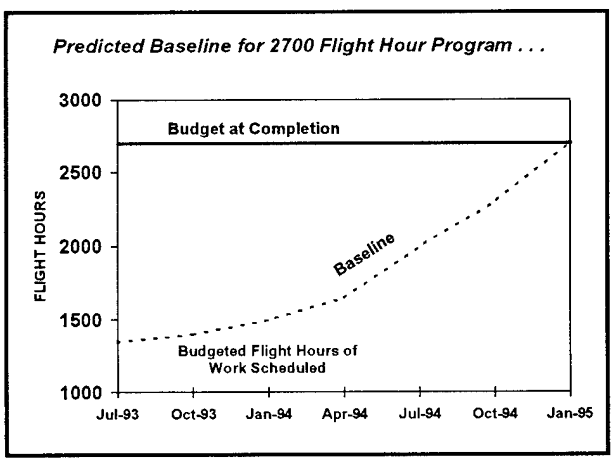

Figure 7: Flight Test Program Management Baseline

track progress and determine impact of changes on the overall schedule. The baseline can be expressed in terms of work effort (test-point hours) or cost (flight hours). As previously described the ratio between the two is flight test efficiency that is initially assumed for planning but is measured once testing begins. The "cost" of the entire flight test effort can be estimated and "budget at completion" is used to control the flight test effort. Figure 7 shows an example program baseline in terms of cost for a 2,700 flight hour test program.

Step 5: Execute the Plan

Following coordination of the flight test baseline with the program manager, execution of the schedule begins. The flight test manager must now inform the program office when a breach in the baseline occurs. A breach is an anticipated overrun in cost or schedule by a predetermined amount. Action to resolve the breach may require additional resources, management attention, and may even involve a re-baselining of activity.

As work packages are completed, credit for the value of the work is taken using the test-point hours that make up the work package. This is the earned value aspect of the system. Despite the cost in flight hours, only the test-point hours budgeted for that specific work effort measure the value added by flight test.

Use of earned value to measure the work effort provides a more complete indication of flight test status. For example, if 2,000 test-point hours of work define the program, accomplishing 500 test-point hours means 25% of the flight test work is complete. This is a much improved measure of progress when compared to counting flight test hours or test points completed. During execution, a set of flight test metrics is generated to chart progress. Example metrics are shown in Figure 8.[22] These metrics can be used by all levels of management to determine status

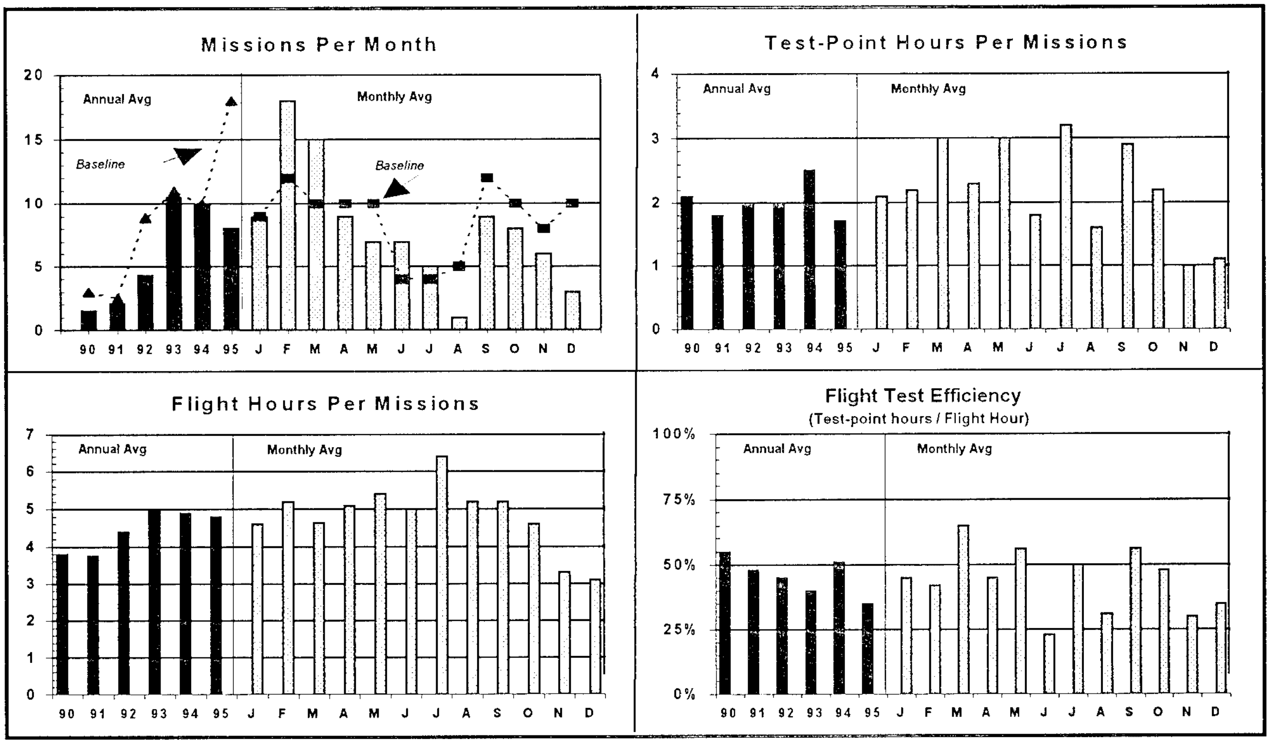

Figure 8: Examples of Flight Test Metrics

and in decision making. In addition, these same metrics can be used to brief agencies with oversight authority on progress of the program. The flight test manager can monitor performance against the baseline and make better informed decisions. The addition or deletion of test requirements can be evaluated against effects on the entire flight test program or intermediate milestones.

Implementation

Obviously in a large program such a system cannot be performed by hand because variables and interactions number in the thousands. Use of PC based project management software is a necessity. The project management software should allow the construction of WBS and networks, specifying priorities and resource allocation, and generating reports and metrics. These systems typically measure cost in "dollars" but test-point hours can be substituted.

In addition, the flight test team will need training in the concepts of earned value, WBS, and systems engineering concepts. Training should include how to use and interpret the metrics generated to determine status and schedule of tests.

RESULTS

Don't try to innovate for the future. Innovate for the present! [23]

—Peter F. Drucker

In 1991, the B-2 flight test program at Edwards AFB faced a significant increase in complexity due to continued high visibility and oversight from DOD and Congress, an ever expanding test matrix, receipt of additional test vehicles (each different in configuration and purpose), and the need to

fly each aircraft more than once a week. The program suffered from the same malady afflicting other flight test programs–a short term view and the inability to project further than several weeks or months into the future. The "planning system" in place would not adapt to an increase in complexity. The program was composed of 15,000 test points, 3,600 flight hours, 6 flight test vehicles, and a test team of almost 2,000 people. A project management system was needed to efficiently use flight test hours, meet schedule, predict shortfalls in cost or schedule, and report progress.

The flight test team set out to develop a risk management system with a compatible set of planning tools capable of accommodating the increase in program complexity. The system approach described in this paper was used.

There were many obstacles along the way. The flight test culture inbred at Edwards AFB took several months to overcome. Many did not understand the principles fundamental to the system. The metrics initially devised to plan, control, and report progress were inadequate and required continuous refinement. Finally, the logistics and ground test activity were not modeled or incorporated into the flight test model. This has become the biggest risk to schedule as aircraft downtime and the maintenance work that needs to be performed are continually underestimated. These areas will require additional work and ideas.

It has been almost four years since this system was developed. During this period additional transformations in the flight test program have taken place. Each was necessary due to the evolution in the program along with real world developments unforeseen in 1991. Integrated Product Teams (IPTs) were incorporated (see Figure 4) and empowered with a budget of test-point hours to conduct their tests. The IPTs, using metrics from the management model, are now accountable and must manage within budget or project overruns. The flight test model is used to integrate between the functional areas and determine impact on test schedule and overall budget.

Quality improvements necessitated this evolution. The success of future flight test activity will require the test community share the responsibility for risk management. Flight test teams must incorporate this viewpoint into their program. The method described in this paper is a proven system. Other tools await development. Although each application must be tailored to the program and weighed against the costs and the benefits, enhanced control over the estimate and management of the project will result by adopting this approach. Future flight test programs should consider incorporating such a model to assist in risk management.

ENDNOTES

[1] Tom DeMarco, Controlling Software Projects: Management, Measurement, & Estimation (Englewood, N.J.: Yourdon Press, 1982), 3.

[2] The traditional concerns for program management are cost, schedule, and performance. Several years ago the Defense Systems Management College and the acquisition community added "supportability" as a fourth criterion to acknowledge the importance of integrated logistics support. Performance and supportability are contained in effectiveness which is made up of capability, dependability, and availability. This paper addresses the impact to and tradeoffs between cost, schedule, and effectiveness criteria.

[3] Major weapon system acquisition programs are divided into five phases: concept exploration and development, demonstration and validation, engineering and manufacturing development, production and deployment, and operations and support. Although testing is found in each of these phases, testing during the engineering and manufacturing development phase (formerly known as the full scale development phase) is performed on a preproduction system and is concentrated at the total system level. The focus of this paper is on test activity during this phase. See DOD Directive 5000.1, *Defense Acquisition*, 23 February 1991 for a description of the phases of acquisition programs. Large, high visibility program refers to a major weapon system acquisition program as defined in DOD Directive 5000.1. See Defense System Management College, *Test and Evaluation Management Guide* (Ft Belvoir, Va.: DSMC Press, March 1988), Chapter 1, 1-5 for a description of test activity during each phase.

[4] For the purpose of this paper the following definitions will be used. The "program manager" is the individual responsible for the technical, business, and administrative management of a defense acquisition program. This individual is in charge of the system program office that provides the responsible test organization with a cost, schedule, and effectiveness baseline for the testing activity. The "test manager" is the individual responsible for the conduct and execution of the test and manages the test program within the cost, schedule, and effectiveness criteria.

[5] SPO is System Program Office, the organization composed of technical, administrative, and business management personnel assigned full time to a system program director. See AFI 99-103, *Air Force Test Process*, 25 July 1994, 13.

[6] Author's observations based on 7 years of flight test experience on 2 major flight test programs at Edwards Air Force Base.

[7] AFMCR 500-11, *Commander's Policy: Integrated Weapon System Management*, 1 November 1992; Integrated product development consists of empowered integrated teams working across the traditional functional management structure to provide a cost effective, quality, and timely product. See also AFMCR 500-19, *Commander's Policy: Integrated Product Development*, 21 April 1993. See AFI 99-103, *Air Force Test Process*, 25 July 1994 for a description of Single Face to the Customer.

[8] Integrated product teams are the agents of integrated product development.

[9] The process was introduced in 1991 and incorporated as a planning tool to manage the B-2 flight test program at Edwards Air Force Base. For details of its development and evolution see Charles H. Thornton and Perry L. Lamy, "Measuring Flight Test Progress on Large Scale Development Programs," (Paper presented at the 6th Biennial AIAA Flight Test Conference, Hilton Head, S.C., 24-26 August 1992) and Charles H. Thornton, "Program Management and Control of the B-2 Flight Test Program," (Paper presented at the 7th Biennial AIAA Flight Test Conference, Colorado Springs, Col., 20-23 June 1994).

[10] George Lucas, dir., *Star Wars*, starring Carrie Fisher and Harrison Ford (Los Angeles: 20th Century-Fox Film Corp., 1977).

[11] Raymond W. Reig, "Insufficiently Robust DT&E Means Troubles Ahead for

OT&E," *Program Manager* 23, no. 4 (July-August 1994): 12-13.

[12] FY 94 costs to operate the government side of a large combined test force at Edwards AFB was approximately $70M. This includes civilian pay, contract services support, equipment, jet fuel, travel cost, test support services, and supplies. It does not include military pay or the prime contractor's cost for about 1000 people on site.

[13] Bernie Rudwick, "Management Control of Development Programs," lecture, Defense System Management College, Fort Belvoir, Va., 23 Oct 1990. See Defense System Management College, Technical Management Department, "Risk Management as a Means of Direction and Control," Fact Sheet Number 4.5, November 1988 in *The Program Manager's Handbook* (Fort Belvoir, Va.: DSMC Press, March 1989) for a description of risk management tools and techniques.

[14] AFI 99-101, *Development Test and Evaluation*, 22 July 1994, 4.

[15] AFI 99-103, 2.

[16] Air Force Flight Test Center, "Test Planning and Reporting," AFFTC Project Managers Course, Oct/Nov 1991, 2-3.

[17] Commitment to Excellence,(Lombard, Ill.: Great Quotations, Inc.), 16.

[18] For a simple and understandable description of Cost Schedule Control System Criteria (C/SCSC) see Lt Col William J. Niemann, "If the Pharaoh Had Only Used an Earned Value System in Building the Pyramids," *Program Manager* 11, no. 3 (May-June 1982): 3-7.

[19] For a description of the Program Management Document, the Test and Evaluation Master Plan, and other significant program documents, see AFI 99-101.

[20] Defense System Management College, Technical Management Department, "Work Breakdown Structure (WBS)," Fact Sheet Number 1.7, November 1988 in *The Program Manager's Handbook* (Fort Belvoir, Va.: DSMC Press, March 1989), 1.7a.

[21] PERT is an acronym for Program Evaluation Review Technique. It is a tool for program management from start to completion by constructing a network model of integrated events, milestones, constraints, and activity. It includes the periodic update and evaluation of the cost and schedule implications of program progress and setbacks. Wilbur D. Jones, Jr., *Glossary: Defense Acquisition Acronyms and Terms* (Fort Belvoir, Va.: DSMC Press, July 1987), 67.

[22] Data shown is notional.

[23] William Safire and Leonard Safir, eds., *Leadership* (New York: Simon and Schuster, 1990), 120.

REINVENTING PROCUREMENT PERFORMANCE MEASURES

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ABSTRACT

In these times of innovation and change, a rethinking of oversight and performance measurement concepts is both important and timely. An interagency team of procurement professionals was commissioned by the Procurement Executive Association (PEA) to assess and reexamine the state of the current system and to identify innovative approaches to measuring performance. The Procurement Measurement Action Team (PMAT) devised a "new" methodology for assessing and improving the health of procurement systems. The Procurement Performance Measurement Model focuses much more attention on outcomes and results and advocates the use of benchmarking and reengineering as an effective process to foster dramatic change in performance. The model is, by design, much different from conventional assessment mechanisms such as procurement management reviews. It focuses on high impact measures. It is balanced, and puts the emphasis on prevention rather than detection. It is customer-oriented and cross-functional in that it is not limited to areas of direct control.

INTRODUCTION

On March 17, 1982, President Reagan signed Executive Order 12352, "Federal Procurement Reforms" and tasked each agency to ensure effective spending of public funds. The executive order required Federal departments and agencies to, among other things, name a procurement executive who would be required to establish criteria and performance standards for evaluating the respective agency's procurement system and for certifying the adequacy of such systems. Subsequently, system criteria guidelines were established by the Office of Federal Procurement Policy (OFPP) in 1984 to serve as guidelines for agencies in establishing criteria for their procurement systems.

System evaluation criteria became the enabling methodology for department and agency system certifications through on-going "Acquisition" or "Procurement Management Review" (PMR) programs. Most agencies utilize PMRs of procurement organizations to determine compliance with these established criteria and to certify the adequacy of the procurement system. However, this method is expensive and time consuming and focuses on compliance

rather than focusing on the desired results of agency procurement systems. Additionally, this method has not proven particularly effective in obtaining dramatic and sustained improvement in the quality of the procurement operations.

More recently, Vice President Gore's National Performance Review (NPR) established a goal of moving from red tape to results to create a Government that works better and costs less. NPR guiding principals envision four key objectives: (1) Cutting red tape, (2) Putting customers first, (3) Empowering employees to get results, and (4) Cutting back to basics. The NPR identified a number of procurement reforms to simplify and streamline the acquisition process. These reforms are intended to radically decentralize authority to line managers, letting them buy much of what they need, and simplify procurement regulations and processes.

On August 3, 1993, the President signed the Government Performance and Results Act of 1993. It requires agencies to devise five year strategic plans setting forth their mission and long term goals. Agencies are also required to establish annual performance plans and to measure how well they actually perform in accomplishing agency goals. On September 11, 1993, the President also signed Executive Order 12862, "Setting Customer Service Standards" requiring reform of the executive branch's management practices and operations to provide service to the public that matches or exceeds the best service available in the private sector. The executive order requires all executive departments and agencies that provide significant service to the public to survey their customers and to benchmark customer service performance against the best in business.

Recognizing the need for innovation and change, the Procurement Executive Association (PEA) commissioned a working group composed of civilian agency procurement personnel to assess the state of the current system; identify innovative approaches to measuring performance; and to develop recommendations for measuring the health of agency acquisition systems. The PMAT consists of representatives from Treasury, Transportation, General Services Administration, Commerce, Health and Human Services, and the U.S. Mint. This paper presents the results of the PMAT efforts to re-invent the Federal performance measurement model.

PERFORMANCE MEASUREMENT ACTIVITY

The PMAT began by conducting basic research in performance measurement. Research conducted by the PMAT consisted of general readings, site visits to industry, contacts with state and local governments, academia and formal classroom training in developing performance measures and in benchmarking. Contact with industry revealed the use of operational performance measures in combination with the more common and traditional financial measures. Customer input was also sought, measured and used as a tool for improving performance. Differences in the fundamental mission of the purchasing activities in government and the private sector were found to be negligible. Industry's growing use of benchmarking as a measurement tool was also noted and documented including the requirement for an established benchmarking program as a prerequisite for the Malcolm Baldrige

Award. Interest in benchmarking is likely to grow exponentially, eventually becoming standard business practice.

Benchmarking is the continuous process of analyzing, measuring and assessing an organization's performance against the "best" for the purpose of instituting dramatic and sustained performance. The International Benchmarking Clearinghouse, a service of the American Productivity and Quality Center in Houston, Texas, which has researched and written extensively on the use of benchmarking, defines benchmarking "as an ongoing measurement and analysis process that compares internal practices, processes or methodologies with those of other organizations." The purpose of benchmarking studies is to identify best practices that may be adapted to a wide range of organizations. The identification and use of best practices leads to the dramatic process improvements associated with benchmarking efforts. (1)

PMAT examined performance measurement practices at Eastman Kodak and Texas Instruments. "Procurement benchmarking" conducted by the Center for Advanced Purchasing Studies (CAPS) associated with the College of Business at Arizona State University was also studied. Eastman Kodak Company is benchmarking purchasing functions world-wide. A self-assessment survey is distributed to and completed by Kodak's purchasing units on an annual basis. At this time, Kodak measures performance against established critical success factors. They employ both qualitative and quantitative measures. The results of the effort are used in developing improvement plans through the use of best practices.

Texas Instruments is benchmarking both internally and externally. Purchasing serves as a component on a team approach. Texas Instruments relies upon varied forms of information collection instruments. CAPS was established to respond to the needs of private sector purchasing. They have also expanded their benchmarking services to state and local governments. CAPS is supported by corporate grants. They are benchmarking purchasing in 26 industries, including state and local governments. Industry identifies specific benchmarks to be used in addition to standard generic measures (e.g. timeliness, cost effectiveness, etc.). Many of the metrics have applicability to Federal purchasing and may prove beneficial in comparing Federal procurement with private sector and state and local government procurement.

In developing the Procurement Performance Measurement Model, the PMAT was heavily influenced by an article entitled "The Balanced Scorecard-Measures that Drive Performance" by Robert C. Kaplan and David P. Norton in the January/February 1992 edition of the Harvard Business Review. Kaplan and Norton pointed out the need for a balanced presentation of both financial and operational measures. Kaplan and Norton devised a "balanced scorecard" - a set of measures from four different perspectives that gives managers a fast but comprehensive view of the business. The authors likened the "balanced scorecard" to dials and indicators relied upon in navigating an airplane. A pilot needs to rely on many indicators simultaneously to ensure the steady flight of the airplane. The "Balanced Scorecard" links performance measures from four perspectives: Customer, Financial, Internal

Business, and Innovation and Learning. Figure 1 depicts the Kaplan and Norton model. (2)

PROCUREMENT PERFORMANCE MEASUREMENT MODEL

The Procurement Performance Measurement Model developed by the PMAT is presented in Figure 2. The model was designed to assess the primary role of the procurement system: to provide a quality product or service at a good price within timeframes necessitated by the customer. The model uses the Kaplan and Norton balanced scorecard, with some modification, to link performance measures from five perspectives: Financial, Customer, Internal Business, Innovation and Learning and Employee Empowerment. Within the five perspectives, eleven performance goals are identified as critical success factors for procurement organizations. Key measures and data collection methods are identified for each goal. Each goal has at least one corresponding counter balance goal. For example, successful accomplishment of "Timeliness" may impact upon organizational performance in a number of other goals, including but not limited to: "Quality of product", "Acquisition Excellence", or "Quality Work Environment".

In developing the model, each goal and corresponding measure is well defined by PMAT. In many cases the goal and measure are self-explanatory. "Acquisition Excellence" speaks to the optimum quality of the procurement process. The measure assesses the extent to which internal quality systems (designed to ensure an effective and efficient acquisition process) are in place. "Maximize Value at the Least Cost" is intended to maximize the value of the procurement system relative to purchasing costs. The cost to spend ratio (i.e., purchasing costs as a percentage of contract dollars spent) is used as the key measure in assessing the cost-effectiveness of the procurement process. "Maximize Cost Savings" relates to the verifiable savings or avoidance of cost through the deliberate efforts of the procurement office. The ratio of dollars saved or avoided as a percentage of contract dollars obligated is used as the key measure.

The model was designed to be relatively simple and inexpensive to conduct a comparative assessment of organizational performance. Four methods of data collection are used. A Customer Survey is used to collect internal customer perceptions relating to timeliness of product (e.g. on-time delivery defined by the customer), quality of product (e.g. quality of product as defined by the customer), and responsiveness of procurement to customer needs. An Employee Survey is given to all employees of the procurement organization to assess perceptions relating to the work environment and executive leadership. A Self Assessment is completed by the senior procurement official in the organization to rate and assess performance against Quality Workforce, Mission Planning, Acquisition Excellence, and Data Collection goals. Statistics obtained from the Federal Procurement Data System and the procurement organization are used to develop the cost to spend ratio and purchasing influenced savings.

The PMAT used the services of experts, such as the Joint University of Maryland-University of Michigan program in Survey Methodology to develop the Customer and Employee Surveys. Both surveys use a

standard approach to data collection. Respondents are asked to rate their level of agreement and level of importance associated with each survey statement. Self Assessments developed by Eastman Kodak Company and Texas Instruments were used as a model for PMAT self assessments. The Self Assessment survey contains a series of specific measurable statements associated with a performance goal (e.g. Quality Workforce). The statements reflect differing degrees of performance with a particular subject matter. The senior procurement official selects the statement(s) reflective of his organizations performance. A rating (from 1 to 5) is subsequently assigned to each response.

A methodology for using the model as an effective tool to measure and enable continuous change was developed by PMAT. Information collection and presentation of results is primary research. Once complete, the information is used to ascertain how an organization compares with other organizations and identification of best-in-class, in eleven performance areas. The organization is then free to identify opportunities for improvement. Benchmarking identifies best practices. Benchmarking with the best-in-class accelerates the process of change and fosters breakthrough improvements.

After the initial development of the Procurement Performance Measurement Model, the PMAT conducted a BETA test in fourteen procurement offices in six civilian agencies. The purpose of the test was to validate the performance goals, measures and the survey instruments. Over 500 employees, in their capacities as internal customer or procurement personnel, participated in the test. To ensure consistency in the deployment of the test, PMAT teams followed a very structured approach in presenting and administrating the data collection. An executive briefing was provided to senior management on the purpose and scope of the test. PMAT provided customer and procurement staff with a briefing on the Procurement Performance Measurement Model, how it was developed and its intended purpose. An overview on the process of benchmarking was also provided. At the conclusion of the briefings, the employee and customer surveys were administered. The senior procurement official was tasked with completing the self-assessment.

Unlike a typical PMR, PMAT performed data analysis on-site and provided all participants with test results within a day of data collection. A glyph was used to present a report card for each procuring organization tested. A glyph is a tool used in Total Quality Management to evaluate several different alternatives based on three or more quality characteristics. PMAT's approach to presenting the results in a glyph was reflective of performance measurement work conducted by Eastman Kodak Company. Figure 3 is a representation of a PMAT glyph. The implications of the report card will be discussed shortly. PMAT presented the results of the data collection in focus groups held jointly with customers and procurement staff. The focus groups also provided excellent feedback to the PMAT on the utility of the Performance Measurement Model, including data collection instruments.

As a result of the testing and obtaining feedback in focus groups and other sources, PMAT concluded that the goals reflected the critical success factors of the

procurement organizations. Participants observed that the model measured the right things. PMAT also found the performance measures valid in assessing achievement of performance goals. The majority of test participants indicated that the assessment reflected their perceptions of their organizations performance. After conducting the test, PMAT concluded that the Procurement Performance Measurement Model, with minor adjustments identified during the test, could provide an effective tool that measures the overall health of the procurement organization. The model provides specific measures which indicate superior performance as well as areas that could be targeted for improvement based upon input from management, employees and customers.

DATA ANALYSIS AND IMPROVING PERFORMANCE

The data obtained from the customer survey, employee survey, self assessment and statistics are all considered to determine how effectively a procurement organization met the performance goals. Upon conclusion of the test, PMAT collected and normalized the data from all test sites. Figure 3 presents the results of the data collection for one of the procuring organizations. The data is normalized. The glyph is reporting on how the organization stacks up with other procurement organizations in thirteen performance areas. The closer to the center of the glyph the better the performance. The shaded area represents the performance outcome for organization "A". The dotted line represents the average of all tests sites.

In the area of customer perspective, organization "A" is doing quite well. Organization "A's" internal customers are most satisfied with the timeliness of product or services; quality of the product or services and with the responsiveness of the procurement organization. In fact, this organization may be best in class for Customer perspective. Employee perspective is reporting mixed results. Under "Executive Leadership" employee perceptions indicate operations are conducted in an efficient, professional and ethical manner. Nonetheless, there may be opportunities for improvement with the quality of the work environment. There may also be targets for improvement under "Acquisition Excellence", "Accurate and Timely Data Collection", and the goals under the Financial Perspective.

As previously discussed, conducting the assessment is designed to be the first step in improving performance by providing information on how the organization compares with other procurement organizations for the purpose of identifying best practices in critical success areas. The assessment is primary information collection. Procurement organizations use this information to immediately identify areas of weakness and begin efforts to review their processes. This approach to improvement is participatory and empowers the organization to identify what's important. Process mapping will assist the organization to better understand the process, identify areas of high impact that need improvement or reengineering, streamline the process by immediate elimination of duplication or obvious inefficiencies and identify potential benchmarking topics. Comparisons to the best-in-class will identify what is possible. Benchmarking with the best in class will permit breakthrough improvements and establishing goals of becoming best-in-

class. The benefits of benchmarking are enormous. It allows the organization to accelerate the process of change and accomplish breakthrough improvements. It adopts best practices of organizations recognized for excellence and improves upon them.

As noted above, benchmarking is viewed as a key critical component of the PMAT Procurement Performance Measurement Model. PMAT also developed a "tool box" for use by the practitioner in effecting change. Each performance goal is supported by a key measure and tools for further analysis. Figure 4 represents the "Timeliness" goal and tools for further analysis. In cases where the "timeliness" key measure indicates improvement is needed, the organization should carefully examine the process for possible benchmarking or rengineering efforts. Cycle time or procurement administrative lead-time may also be used for primary data analysis.

IMPLEMENTATION

The PMAT Procurement Performance Measurement Model is being implemented in a number of Federal departments and agencies as a tool in assessing and improving the health of procurement organizations. To be successful in establishing a sustained program, PMAT recommends the following activities:

Coordinated Performance Data Collection. This entails the distribution of data collection instruments to participating organizations. A program for just in time training should be established for all participants. Briefings on the purpose and scope of the model and benchmarking should be provided prior to administration of the survey instruments.

Data Analysis. A central activity should receive and analyze data reports from individual procuring organizations. Data should be normalized and results presented in the PMAT glyph reporting the organization's performance against the measure; mean performance of all organizations participating in the study; and best-in-class performance.

Benchmarking. Participating organizations should be encouraged to participate in benchmarking symposiums and to use benchmarking to improve performance.

Recalibrate. Recalibrate, refine and adjust performance model. Identify new benchmarking opportunities.

CONCLUSIONS

In late 1994, the PMAT reported to the PEA that the final model can be an effective tool in implementing a results oriented approach in assessing agency procurement systems. This model is, by design, much different from conventional assessment mechanisms such as PMRs. The Procurement Performance Measurement Model:

- Focuses on high impact measures.
- Is intended to be easy and economical to use.
- Is balanced and puts the emphasis on prevention rather than detection.
- Is customer oriented.

- Empowers the organization to identify opportunities for improvement.

- Provides performance data on procuring organizations annually.

- Provides for employee input or perspective.

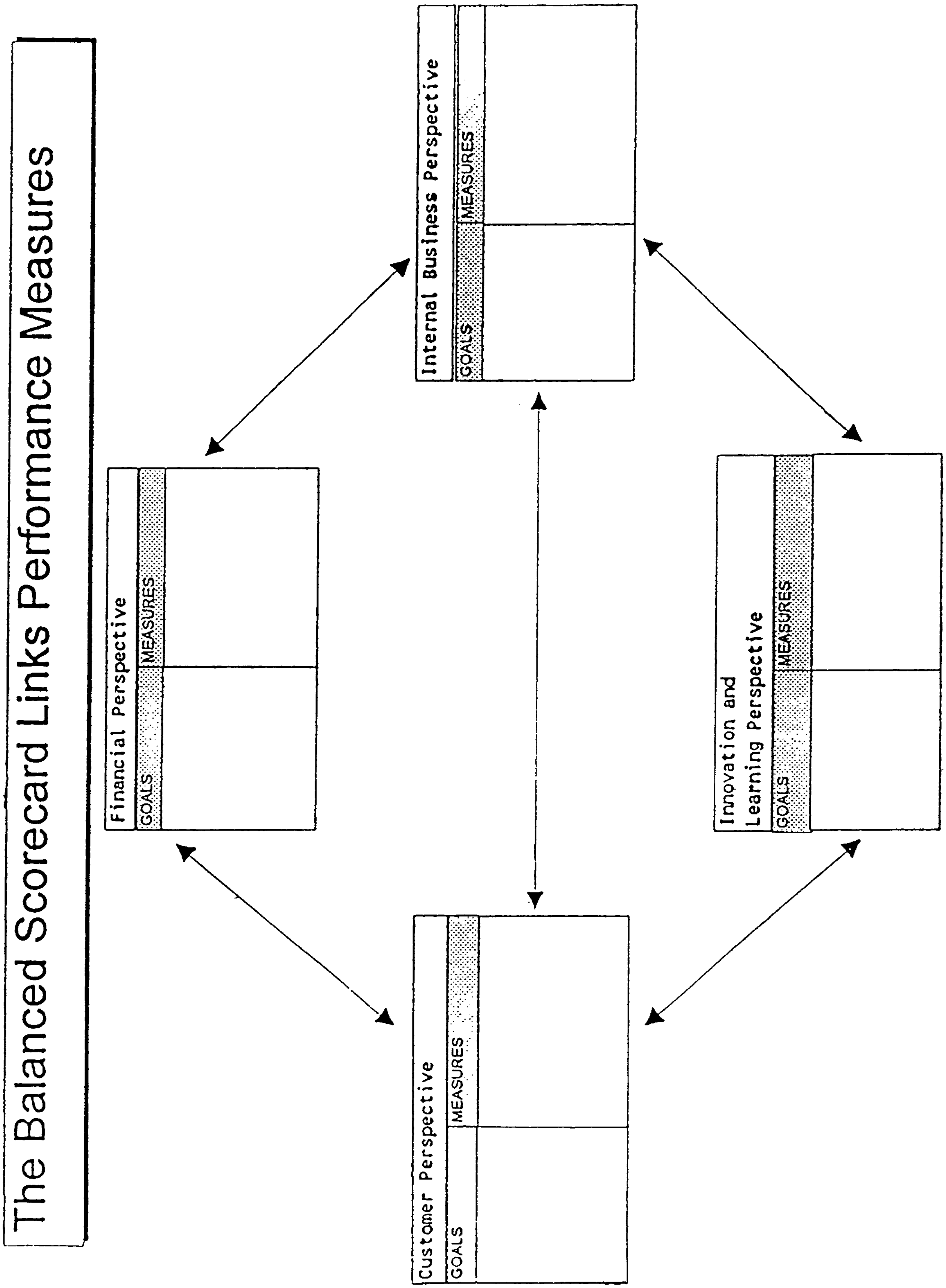
- Recognizes and rewards superior performance.

PMAT also believes that the model can be effective in responding to results oriented performance requirements contained in the Federal Acquisition and Streamlining Act of 1994 (FASA) and Executive Order 12931 as well as the customer focus and best practices contemplated by Executive Order 12862. The FASA requires that OFPP develop results-oriented acquisition process guidelines. Executive Order 12931, "Procurement Reform", replaces Executive Order 12352 and contains a number of requirements that the model would satisfy. Such concerns as focusing more attention on meeting customer needs, developing procurement goals, measuring procurement offices against those goals, promoting innovation and rewarding performance are all addressed by the model.

END NOTES

1. Productivity Press, Inc., The Benchmarking Management Guide, (1993), pp 4 and 5.

2. Harvard Business Review, The Balanced Scorecard - Measures that Drive Performance, January-February 1992, pp 71 - 79.

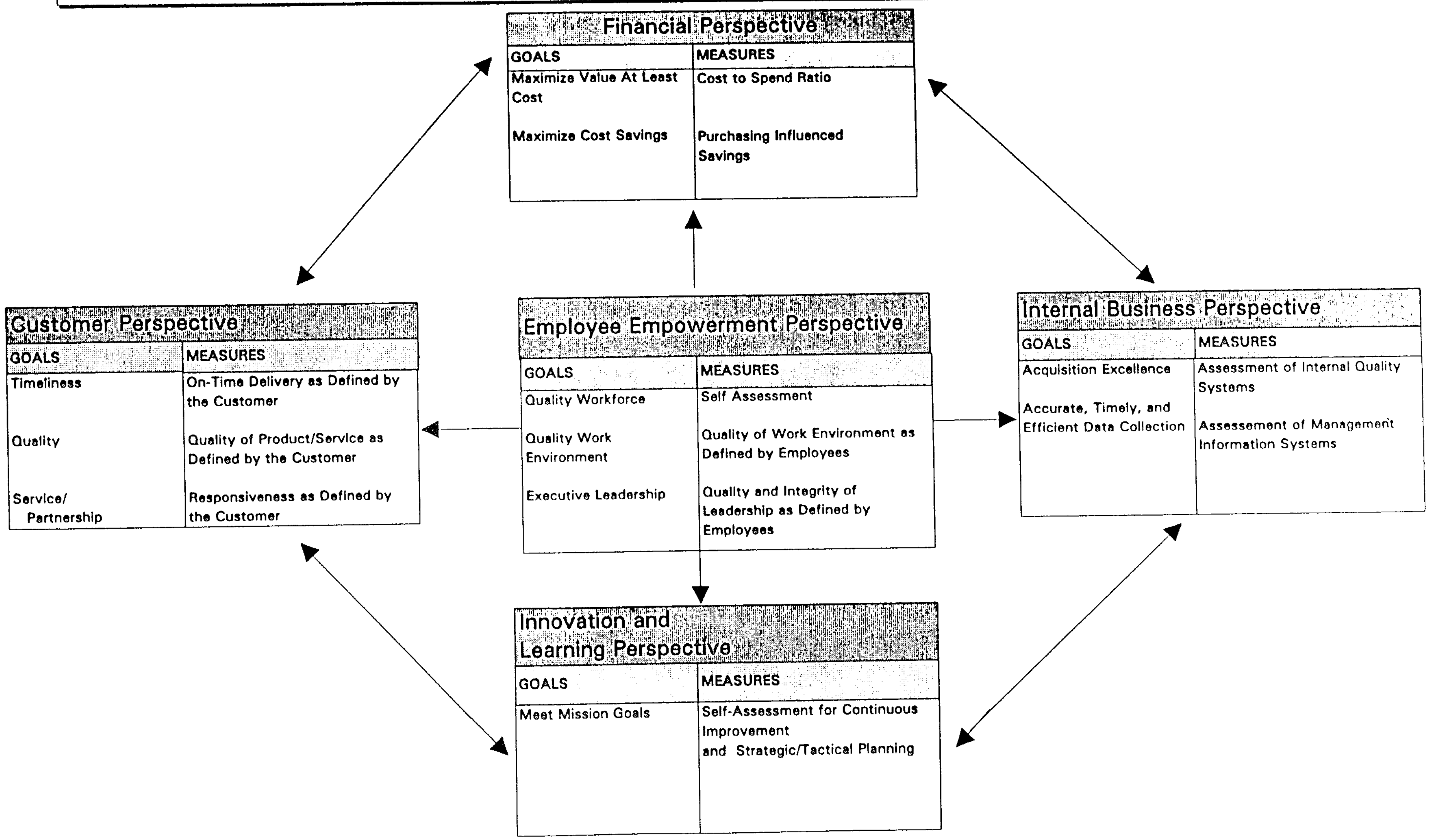


The Balanced Scorecard Links Performance Measures
Financial Perspective
GOALS
MEASURES
Internal Business Perspective
GOALS
MEASURES
Customer Perspective
GOALS
MEASURES
Innovation and
Learning Perspective
GOALS
MEASURES

Figure 1

The Balanced Scorecard Links Performance Measures

(November 1994)



*Adapted from an exhibit contained in "The Balanced Scorecard--Measures That Drive Performance" by Robert S. Kaplan and David P. Norton in the January/February 1992 edition of the Harvard Business Review.

Figure 2

Pursuit of Excellence in Acquisition

A

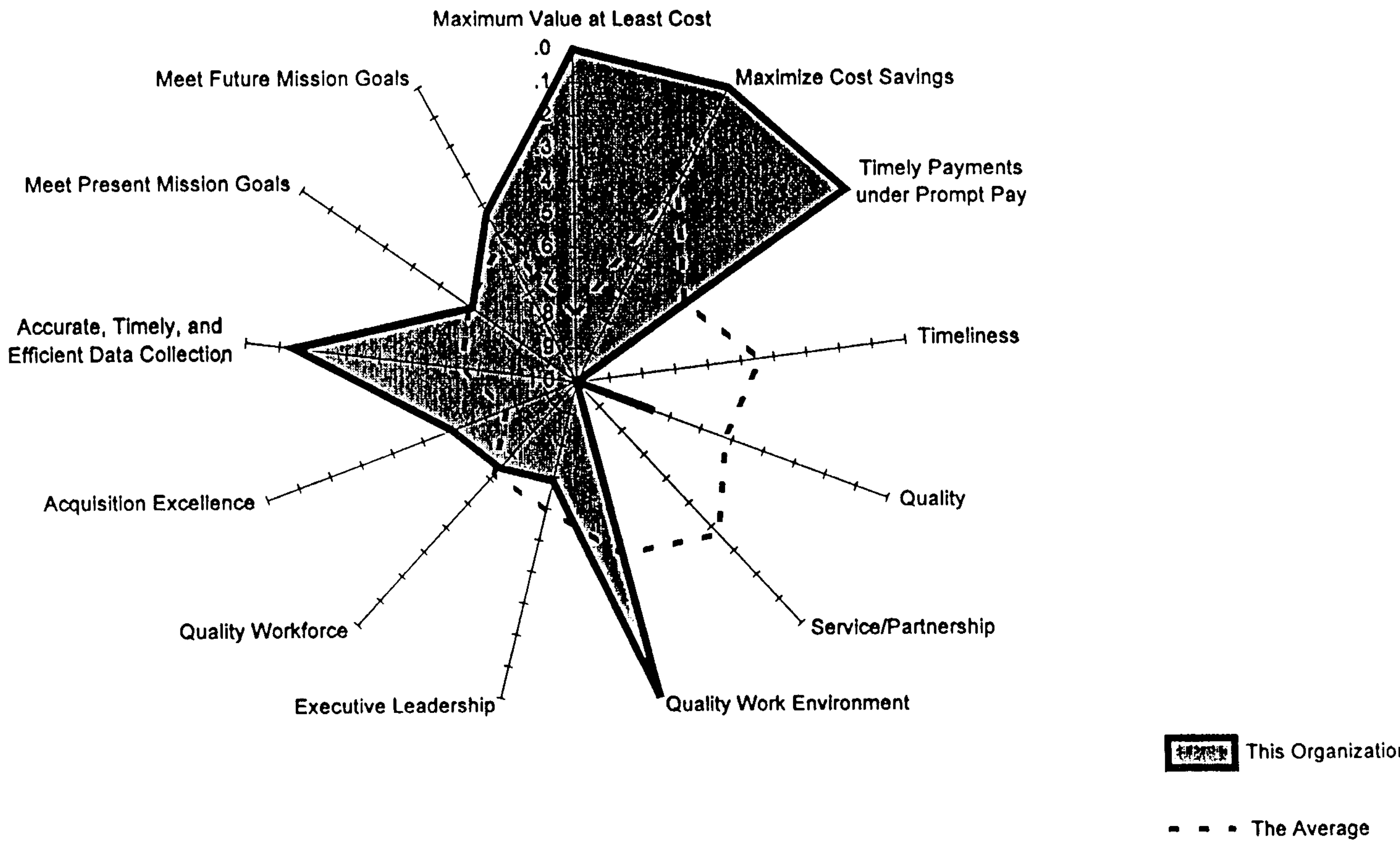


Figure 3

CUSTOMER PERSPECTIVE
TIMELINESS

GOAL: To provide goods and services that meet user needs in a timely manner.

The mission or objective of the acquisition process is to obtain quality goods and services that meet user needs in a timely manner and at a reasonable cost. Timeliness of the acquisition process is a major concern of management as it directly affects the agency's ability to meet it's mission goals. To succeed in conducting timely procurements, it is essential to plan for the acquisition of goods and services needed by the government. The need for procurement planning should be considered for every proposed acquisition and a plan developed where appropriate. Planning activities should encompass the entire acquisition process from the inception of a program to completion of the contract. Coordination between program and procurement personnel on specific requirements, lead times and milestones is essential to ensure that both technical and business aspects are considered.

KEY MEASURE: Customer satisfaction should be used as the key measure in assessing the performance of the procurement system in providing goods and services when they are needed. A customer survey can be used to obtain the perceptions of the customer. For purposes of the survey, customer may include internal users, external users or both. The survey instrument should focus on:

⇒ Customer's degree of satisfaction with the procurement process in delivering products or services on time to meet the needs of the agency. On time delivery is defined by the customer.
⇒ Customer's degree of satisfaction in planning activities including the establishment of lead times and acquisition milestones.
⇒ Customer's degree of satisfaction with on-going communication with procurement staff throughout the procurement cycle on lead time and milestone status.

The key measure results will be used to display the organization's performance relative to the best-in-clkass and average baseline performance.

TOOLS FOR FURTHER ANALYSIS: In cases where key measures indicate improvement is needed, the organization should carefully esamine the process for possible benchmarking or reengineering efforts.

Processing time can be measured especially when customer satisfaction rates are low. It can be measured and assessed either from the standpoint of cycle time or procurement administrative leadtime. Cycle time is the time from program inception to delivery of product or service. Cycle time includes consideration of mission needs, planning, alternatives, budgetary programming, needs descriptions and acquisition. Procurement administrative leadtime represents the time from receipt of a complete and proper requisition through contract award. In either cases, processing time can also be compared by benchmarking accomplishments over time or by comparisons with other similar operations.

Figure 4

SLAD: A SUCCESS STORY IN REENGINEEERING THE ACQUISITION PROCESS

Michael W. Starks
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ABSTRACT

The situation with respect to Survivability/Lethality Analysis in the U.S. Army prior to 1992 is described. Significant problems with that situation are enumerated. The formation of SLAD is exhibited not only as a solution to those problems, but as a more general examplar of a success in reengineering the acquisition process.

INTRODUCTION

I will show that the Survivability/Lethality Analysis Directorate (SLAD) of the Army Research Laboratory is a success story with respect to Reengineering the Acquisition Process. The historical situation with respect to the Army's process for conducting survivability/lethality analyses will be described and problems with that process will be noted. SLAD's organization and operating process will be described as a response to the historical problems. Most of the paper will cover some of the specific lessons --- technical and organizational -- that the Army has learned through transition to a re-engineered process.

Before the formation of SLAD, it was extremely awkward and excessively costly for Army Project Managers (PMs) to obtain the help they needed to ensure that the materiel they were responsible for developing was properly optimized to ensure survivability on the modern battlefield. For survivability in the face of electronic warfare (EW) threats, the premiere organization was the Vulnerability Assessment Laboratory (VAL) of White Sands Missile Range (WSMR). For nuclear threats, the responsible entity was the Harry Diamond Laboratory (HDL) in Adelphi, Maryland. For ballistic threats, the provider was the Ballistic Research Laboratory (BRL) of Aberdeen Proving Ground. For chemical and biological threats, including susceptibility to smoke, the Chemical Research and Development Engineering Center (CRDEC) at Edgewood Arsenal was the place to go. Each of the organizational entities mentioned thus far was a hands-on provider of survivability analysis to Army PMs and to the Acquisition Process. In addition, there was a Survivability Management Office (SMO) and a Vulnerability Lethality Assessment Management Office (VLAMO); these offices were trying to perform the Herculean task of coordinating the various survivability needs.

Unmentioned so far are the providers of survivability technology in the Army's various Research Development and Engineering Centers (RDECs) as well as Test and Evaluation Command (TECOM) which is responsible for some of the Army's survivability testing. In addition, Training and Doctrine Command (TRADOC) centers and schools are responsible for developing survivability requirements for Army systems. The survivability situation was sufficiently confusing that in 1991 the Deputy Commanding General of the Army Materiel Command commissioned a major outside review of what was then called the Vulnerability/ Lethality/Survivability (VLS) methodology and organizational structure. One of the graphics from that review is shown in Figure 1. It is clearly not a pretty picture.

Exacerbating the organizational diffusion was funding inconsistency. Virtually every kind of Program 6 funds were used in support of the activities I have mentioned. Moreover, some of the organizations mentioned had substantial mission funding for conduct of their work while other organizations had almost none.

A final problem with the pre-SLAD environment was more subtle, but also critically important. Some of the pre-SLAD organizations had the attitude that they were part of the PM's team and that their professional goal was to help the PM field the most sur-

VLS TODAY (Figure from 1991 study by Black, Haley, and Hoopengardner)

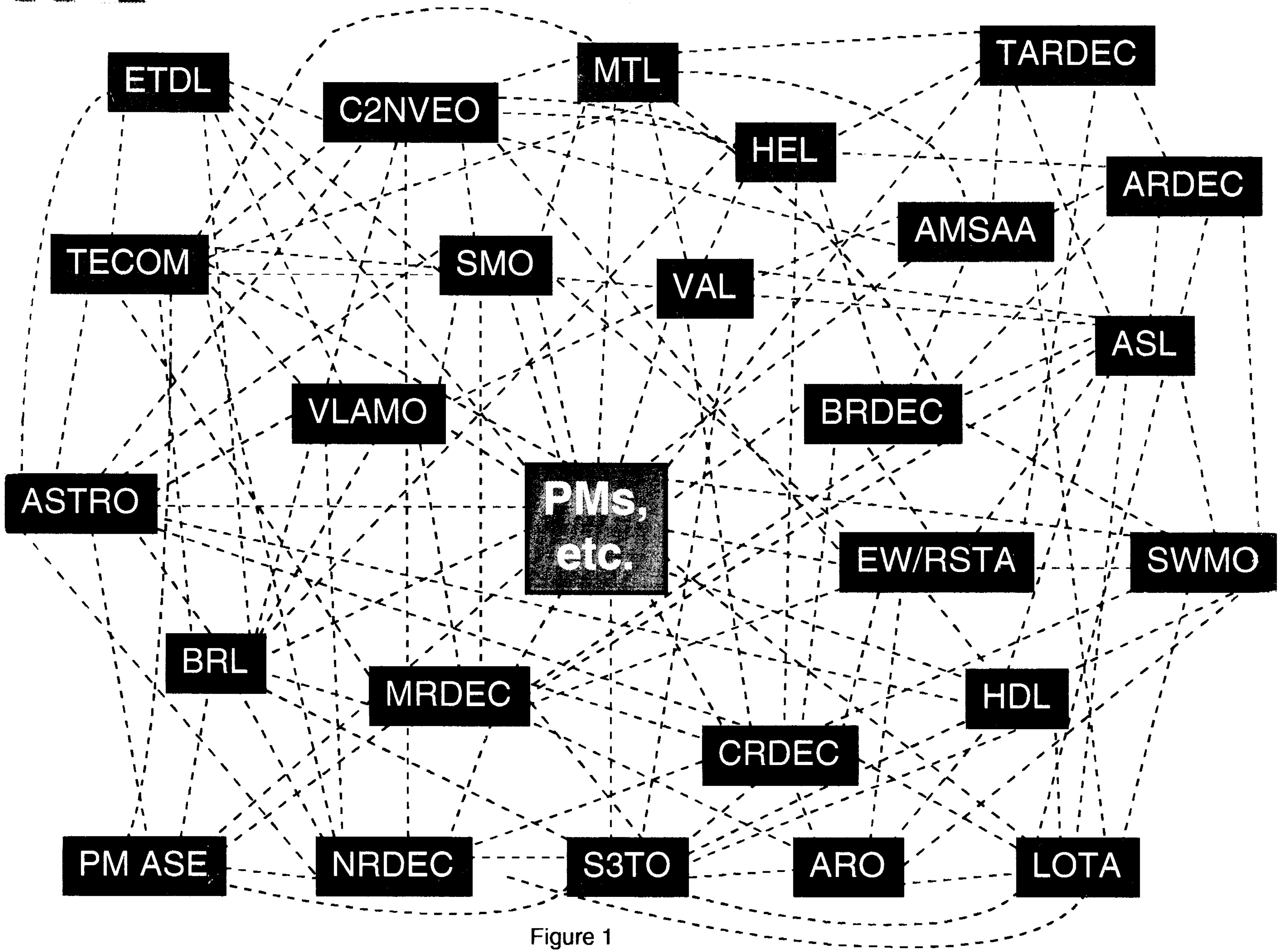


Figure 1

vivable materiel possible. Other organizations had the attitude that they were part of the Department of the Army team which judged whether or not the PM had taken all appropriate action to ensure system survivability. This clash of cultures was not only frustrating to PMs, it also caused a fair amount of sniping across organizational boundaries, and a lack of uniformity with respect to supporting DA goals.

SLAD ORGANIZATION

When SLAD was created, we aimed to provide *one-stop shopping* for all SLA needs. Although the specific expertise in the various survivability disciplines might have to remain geographically dispersed, our goal was to make this geographical and discipline diversity transparent to our customers. As subsidiary goals we also aimed to rationalize the funding for SLAD and to build a single culture (Help PMs? Judge PMs?) for conduct of SLA.

Our primary vehicle for achieving all three of these goals was *integrated analyses,* the planning and resourcing of which was to be implemented by Integrated Analysis Teams. The organizational structure we created to support integrated analysis is shown in Figure 2. The ovals indicate the pre-SLAD organizations who contributed the 500 civil servants, 50 military, and 200 + contractor support personnel who staffed SLAD at its inception in October 1992. Note that the organization is aligned by technical discipline. For purposes of planning and resourcing, however, it is helpful to picture the organization as it is shown in Figure 3. Each area staffer in the Integration Office leads an inter-disciplinary integrated analysis team which typically is populated by cost center managers --- Branch Chiefs --- from the three line Divisions. The teams take the dollar guidance for mission funding they have been given by senior management and conduct a complex planning process for the systems in their purview. Requirements of the supported PMs and of the Independent Evaluators are sought, as are the emphasis areas from HQDA. The teams allocate money versus systems, and also must further allocate the money against discipline --- specific tasks in support of those systems. Programs thus developed are approved or modified by an Executive Steering Committee consisting of the three SLAD Division Chiefs and the Chief of the Integration Office.

During the planning that led to development of this process, we were also able to bridge the cultural gap between the organizations which regarded themselves as helpers of PMs and those with a self-image as evaluators of PMs. We did this by chartering a Process Action Team (PAT) with representatives from PEOs, from the Independent Technical Evaluator, and from SLAD. The PAT developed a very detailed process (Figure 4), according to which SLAD simultaneously makes its data available to the PM (as helper) and to the evaluators. Explicit dispute resolution procedures were also included in the process.

It is worth lingering a moment on the planning scheme I have outlined to make it completely clear how it tends to support achievement of the goals earlier stated. First, the integrated planning process clearly provides the sought after one-stop shopping for Army PMs. All a PM needs to know in order to access needed SLAD support is the name of the Integration Office person responsible for his mission area. Second, the process provides the sought after funding rationalization. On a global basis, SLAD funding guidance is designed both to provide more uniform mission funding support across Integration Areas and to obtain more uniform customer support as well.

It is also worth emphasizing that the integrated planning process just described, and the organizational structure which supports it, was very carefully designed by experienced and senior level practitioners of the various survivability disciplines. This point is important in view of the successes I will attribute to the SLAD process and structure below. Some organizational structures make abstract sense when viewed from a sufficiently high-level perspective, but make considerably less sense when exposed to the crucible of practical application. It is critical to involve experienced subject matter experts in organizational re-engineering both to ensure relevance of organizational structure

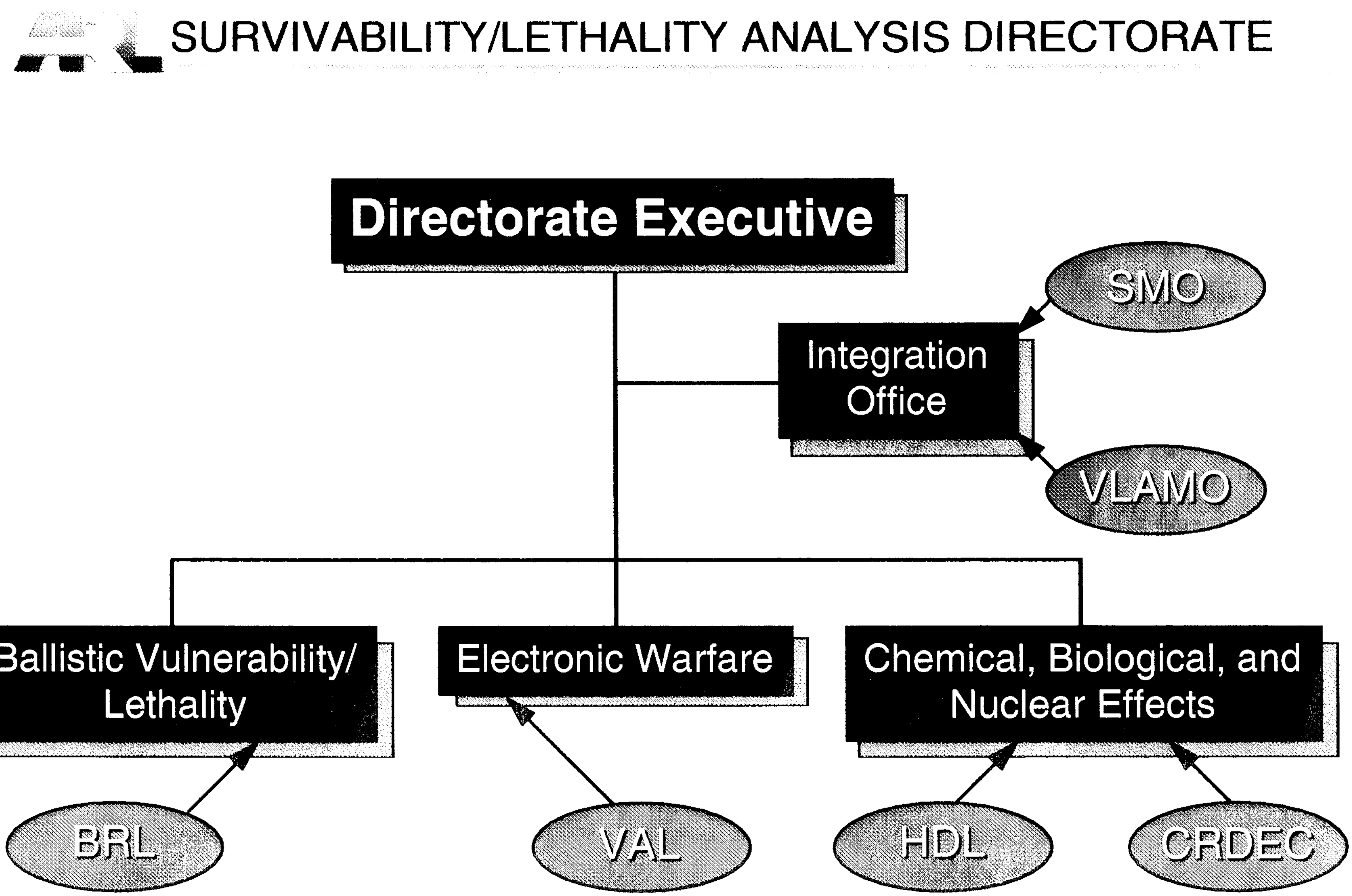

SURVIVABILITY/LETHALITY ANALYSIS DIRECTORATE
Directorate Executive
Integration Office
SMO
VLAMO
Ballistic Vulnerability/ Lethality
Electronic Warfare
Chemical, Biological, and Nuclear Effects
BRL
VAL
HDL
CRDEC

Figure 2

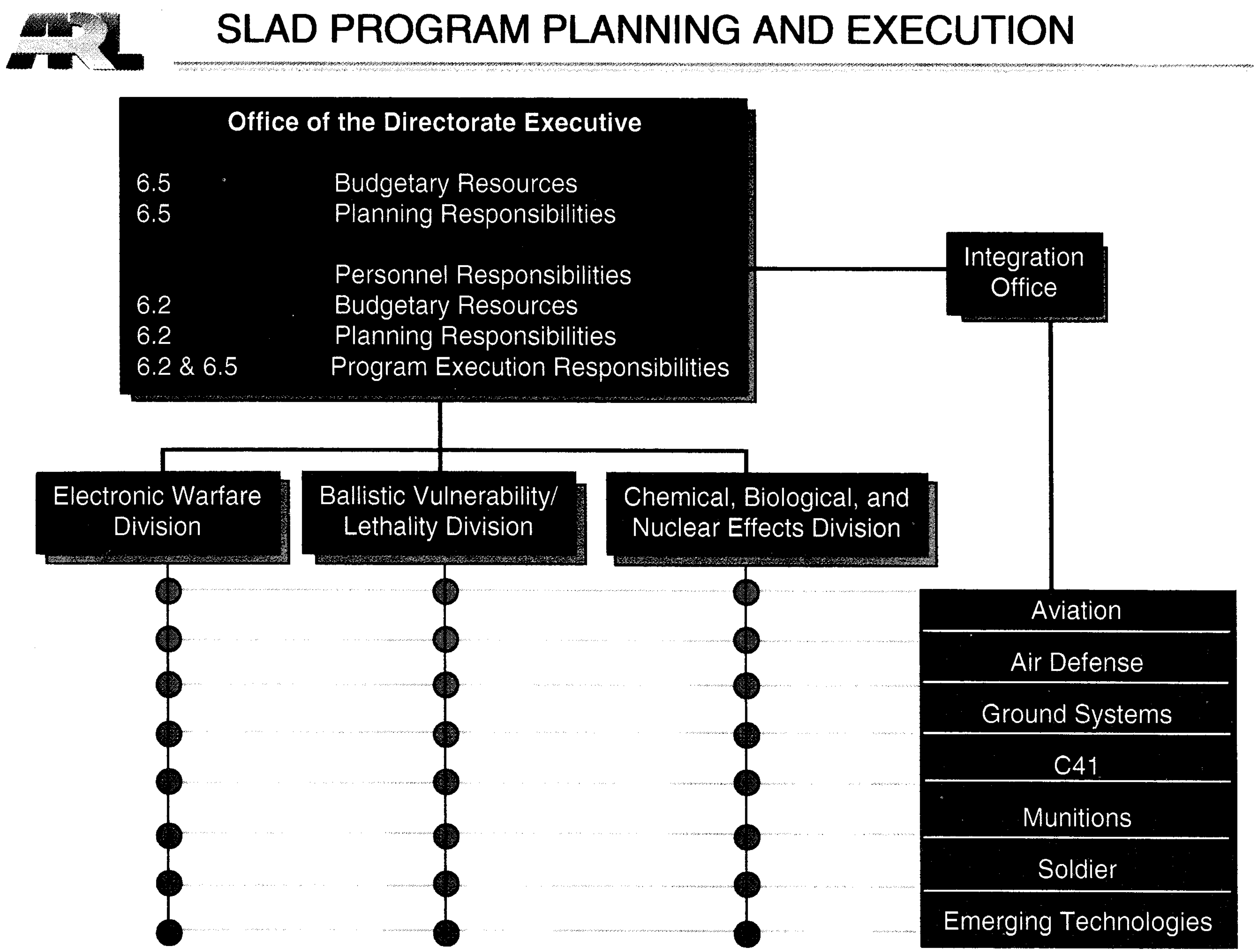
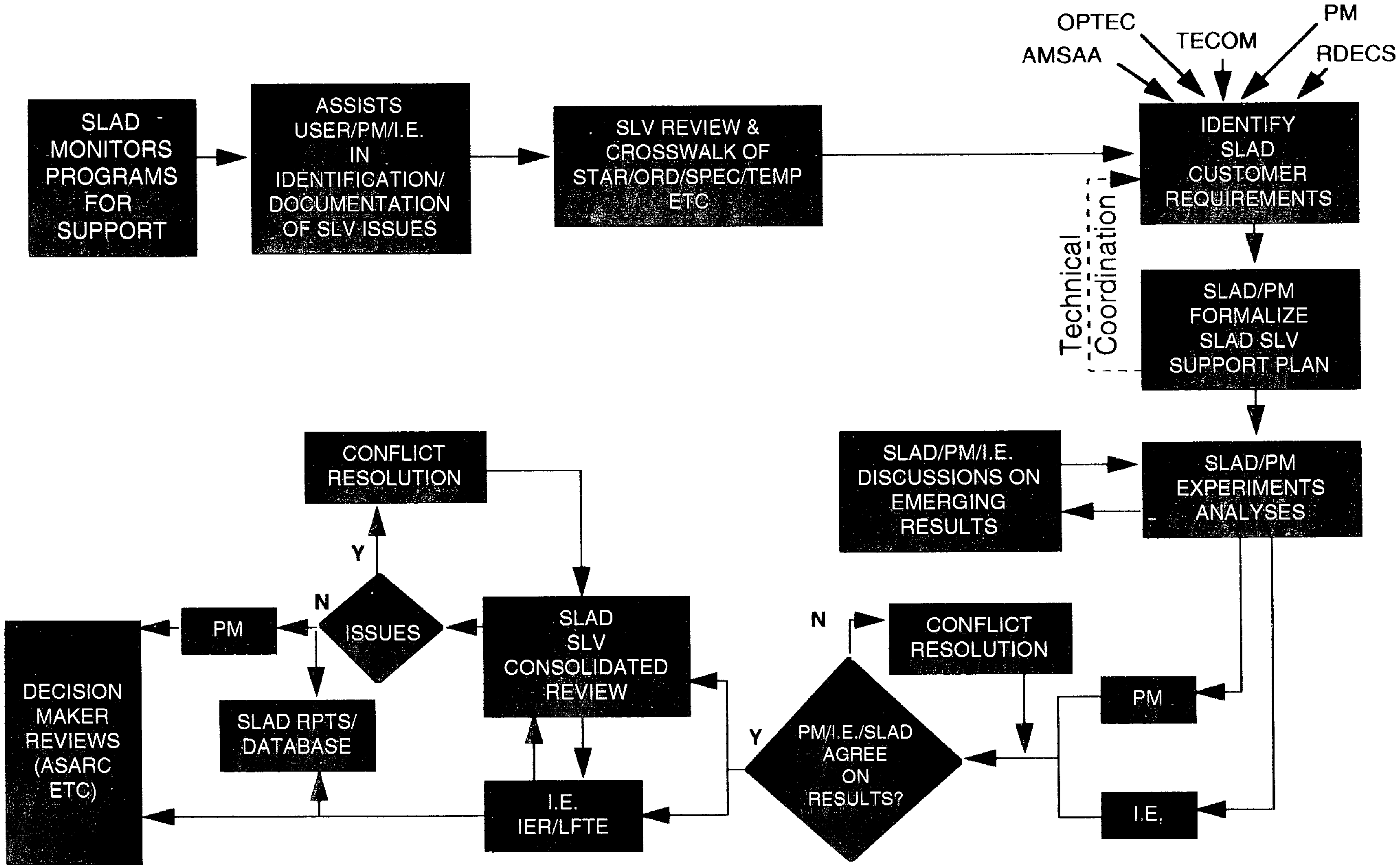

SLAD PROGRAM PLANNING AND EXECUTION
Office of the Directorate Executive
6.5 Budgetary Resources
6.5 Planning Responsibilities
Personnel Responsibilities
6.2 Budgetary Resources
6.2 Planning Responsibilities
6.2 & 6.5 Program Execution Responsibilities
Integration Office
Electronic Warfare Division
Ballistic Vulnerability/ Lethality Division
Chemical, Biological, and Nuclear Effects Division
Aviation
Air Defense
Ground Systems
C41
Munitions
Soldier
Emerging Technologies

Figure 3

SLAD INVOLVEMENT* IN THE ACQUISITION PROCESS



* NOTE: ISSUES/RESULTS WILL BE COORDINATED WITH THE TIWG WHERE APPROPRIATE

Figure 4

and to guarantee that new organization structures will be properly responsive to real-world business problems.

TECHNICAL BENEFIT OF SLAD

We expected to achieve significant new technical synergies when SLAD was formed and we did; I'll give an example below. However, we also obtained substantial synergies which we had not predicted in detail; some of these have greater potential long-term significance than the ones we did expect. I'll give examples of these too. The word "synergy" has been used to characterize everything from corporate mergers to snake oil, so it may be helpful if I indicate what we mean by it in SLAD. We use the word to signal certain kinds of operating efficiencies that resulted from the formation of SLAD; we also use it to describe certain kinds of product improvements.

An example of a synergy we did expect when we formed SLAD concerns handoff of a certain kind of data from our Electronic Warfare Division (EWD) to our Ballistic Vulnerability Lethality Division (BVLD). Historically, the BVLD assumed various simple (i.e. uniform or Gaussian) distributions of hits on targets. Within SLAD, however, EWD has the capability of measuring or simulating actual hit distributions, both for nominal conditions and for various types of electronic countermeasures (ECM). Here is a case where EWD's output becomes BVLD's input, and with a number of desirable consequences. There are no additional costs, the PM gets an integrated answer over the electronic warfare and conventional ballistic disciplines, and the ballistic output is based on more realistic input than before. This last point is particularly critical since the ballistic outputs ("Pks") resonate through the entire downstream analysis process, and are therefore critical to the whole Research, Development, and Acquisition (RDA) process.

Important as realization of this expected synergy is, it is less important than other technical synergies we have gained which were wholly unpredicted. Recall that prior to the formation of SLAD, there were distinct organizational entities responsible for the various technical disciplines: conventional ballistics, electronic warfare, chemical, nuclear, biological, smoke, and environmental. Each of these organizations had a discernibly different culture. There were different ways of posing the global survivability problem, different tools, techniques, and methodologies for solving survivability problems, different vocabularies for discussing survivability problems, and different views as to who the customer set was for survivability products.

Experienced leaders will recognize that it is not possible to overcome cultural differences of the kind enumerated by senior management edict. What has happened is that the process we developed for planning the SLAD program has inherently changed the culture in hundreds of ways, some small and some large. Recall that the SLAD planning process features multi-disciplinary teams led by a Senior Project Officer from the Integration Office, with Branch Chiefs representing each SLAD discipline. During SLAD's short lifetime of just over 2 years, that process has led to remarkable progress towards a unified SLAD culture and to technical synergies that could not have been predicted when SLAD was created.

The fundamental job of the planning teams is to develop and prioritize the work packages supporting each Army system. This requires, for example, that the teams evaluate the relative importance of an electronic warfare work package involving CRUSADER's signature, a conventional ballistics work package involving alternative armor packages, an NBC work package concerning collective protection systems, and an environmental work package concerning the capability of CRUSADER's GPS receiver as a function of precipitation rate. Clearly, a necessary condition on successful accomplishment of the prioritization task is that the team members understand what is to be done in each workpackage and why. In turn, this requires that each team member understand -- not necessarily embrace --- a fair amount of the technical culture of each SLAD discipline. Over time, however, what has happened is much better than merely having the different cultures understand one another. Over time, many of

the participants in the planning process came to believe that it was a waste of energy to devote a great deal of time to translating technical programs into various non-native vocabularies. (Anyone who has engaged in international negotiations using a translator will readily acknowledge this feeling of frustration.) In a mostly spontaneous way, there was progress towards the goal of having a single SLAD description of the survivability problem, a single vocabulary for discussing the technical details, and a single view of the various tools, techniques, and methodologies used to solve survivability problems.

It would be difficult to overestimate the value of the technical synergies that have resulted from the movement towards a single SLAD culture. Inherently, the aspects of the single-discipline cultures, which have become part of the SLAD culture, are those which are clearest, scientifically soundest, and add the most value to Army systems. After all, we are considering hundreds of SLAD scientists and engineers arguing about these matters; the best ideas are the survivors.

The global synergy resulting from development of a more unified culture yields dozens of specific technical synergies with respect to particular problems. Fault trees used to characterize system capability for one discipline are seen to be useful for another. Software for developing solid-geometry target descriptions are seen as more generally useful than originally believed. Comparable metrics of system capability are developed in each SLAD discipline. This gives benefits measured in both increased efficiency and in improved quality survivability products.

In addition to the efficiencies obtained through the technical synergies mentioned, the formation of SLAD also caused efficiencies of a different kind. As SLAD's planning teams developed and prioritized work packages, some types of work packages were consistently accorded relatively low priority, and consequently fell below the funding cut line. This situation permitted us to realize additional operating efficiencies in two ways; we went out of business areas which were lower priority and we were able to reprogram the labor resources saved into higher value-added activity where there were more high priority work packages than personnel to execute them.

For example, our EWD operated an airborne platform (BIG CROW) out of Albuquerque, New Mexico. This was an expensive asset to maintain, was useful for evaluation of relatively few Army systems, and was often used in rote testing rather than sophisticated scientific experimentation. Thus this asset was transferred to TECOM which conducts routine technical testing for the Army. The result was not only greater efficiency for SLAD but for the Army's RDA process.

As a second example, our conventional ballistics division had a substantial team of people engaged in very high resolution force-level modeling for illumination of survivability issues. Many of the work packages prepared by this team did not sift out as high enough priority to be funded. We therefore made the decision to terminate our efforts in that business area and reprogram the labor into improving the utilization of SLAD products within the Army's existing force-level community. As in the first example, the result was improved efficiency not only in SLAD but for the entire RDA community.

In addition to technical efficiencies of the kind discussed, there have been significant administrative efficiencies realized with the formation of SLAD. For example, many Test Integration Working Groups, Internal Process Reviews, quarterly reviews, and other meetings about specific Army systems were formerly attended by each of the five-seven organizations which was involved in survivability for the Army. Now, such meetings can be adequately handled by one-two people, a substantial improvement.

This account of the benefits of SLAD's organization and disciplined planning process would be incomplete without an assessment of customer response. Recall that SLAD's three classes of customers are Army PEOs/PMs, Acquisition decision makers, and the Army's Independent Technical Evaluator. Army PMs have been overwhelmingly satisfied with SLAD's one-stop-shopping concept. Instead of engaging in a half-dozen or more negotia-

tions on each separate aspect of survivability, PMs are able to negotiate their entire survivability program at once, with an upfront guarantee that they will not be blindsided. Indeed, PM enthusiasm about SLAD help is such that SLAD is now a TIWG member and a Test Evaluation Master Plan signatory for every major program. I note that PM satisfaction with SLAD is perfectly consistent with the Defense Department initiative to reduce the need for PM compliance with arbitrary standards and specifications. The world-wide threat is real and evolving, as all PMs know. Moreover, the direction of that evolution tends to be in the direction of U.S. materiel weakness. Neither PM shops nor their supporting Research, Development, and Engineering Centers are staffed with the kind of multidisciplinary survivability expertise which permits SLAD to offer one-stop shopping. For these reasons, Army PMs have eagerly continued to seek SLAD advice even as the community moves away from arbitrary standards and specifications.

The Army's Independent Evaluator (AMSAA) has been very pleased at SLAD's responsiveness to its specific data requirements. Prior to SLAD, AMSAA scavenged for survivability data in a hit-or-miss fashion. Sometimes AMSAA induced PMs to pay for needed survivability data, and sometimes AMSAA employees were forced to make crude guesses to the detriment of the RDA process. SLAD took the initiative to *define* AMSAA vulnerability requirements as part of its Army mission. Since that initiative AMSAA studies have rested on a more consistently credible physical basis than before, and the AMSAA people who conduct such studies have been genuinely appreciative.

Acquisition decision makers have also been well-served by the formation of SLAD. They participate directly in the development, prioritization, and review of SLAD's program; they also reap administrative benefit from the one-stop-shopping concept, especially in the hectic period immediately preceding Milestone Reviews and other significant decision points. Because there is only one organization for SLA, the external coordination requirements are greatly simplified.

One way in which the Army leadership's has shown its satisfaction with SLAD's reengineering of the Acquisition Process, is in giving SLAD new missions and new resources to subject to its disciplined planning process. Since the formation of SLAD we have been given significant new responsibilities in the areas of: system capability as a function of the natural environment; electromagnetic environmental effects (E3); and Soldier Survivability. So it is clear that decision makers prefer SLAD's disciplined planning approach to analysis.

ORGANIZATIONAL BARRIERS

SLAD's reengineering success did not take place without the stimulus of various organizational barriers. Since I doubt that these barriers are unique to SLAD, I believe a few of them merit a brief discussion.

One barrier we faced in creating SLAD was geography. When SLAD was first formed it had significant activity at seven locations in four different states. We are now down to five locations in three states, but the fact remains that our sites are separated by thousands of miles. One might argue that this should be irrelevant in the age of the ethernet and the teleconference (not to mention the telephone and the airplane), but our experience is that it is critical. If a shared culture were already in place then the technological solutions might suffice. In SLAD, however, it was clear that a new culture had to be built. This process proceeded much more slowly than would have been the case if all of SLAD were colocated in one place.

No single silver bullet enabled us to overcome this problem. We had offsites for senior managers and offsites including junior people. We chartered Process Action Teams (PATs) and various working groups which necessitated face-to-face meetings. The Director and Deputy Director each separately visited every cost center (22) in the organization to explain our vision. We enforced the planning process which involved multi-disciplinary teams. And finally, we encouraged Division to Division coordination and integration in every way possible. Much of the difficulty in culture building was garden variety worker resis-

tance to change, but this resistance was much harder to overcome due to SLAD's geographical separation.

A final barrier we had to overcome was resistance to delegated authority from those to whom we were attempting to delegate. As described above, SLAD's planning process forces fundamental prioritization decisions to the lowest possible level in the organization. In the SLAD concept of operations, Senior managers review these decisions; they do not make them. This concept of operations is empowering. It is good Total Quality Management (TQM). But it was resisted, at first, by many of those we were trying to empower. I personally found this surprising. Some employees argued that senior management had abdicated its responsibility; others felt that senior management was trying to trick them into making a mistake.

There is no silver bullet for this barrier either. It took time for the workforce to properly apprehend that it really was trusted and empowered. On many occasions I had to quite explicitly refuse to make decisions which subordinates asked me to make while making the case that a lower organizational level for the decision was appropriate. Eventually, the workforce came to appreciate that they truly were empowered.

GENERAL LESSONS LEARNED

I will highlight two pieces of general advice which have been touched on above and which seem to have more general applicability as we in the Defense Department continue to reengineer the acquisition process. The first has to do with the synergies inherent in multidisciplinary forms of organization; the second with traditional distinctions between "white hat" and "black hat" organizations.

In the discussion enumerating the technical synergies resulting from the formation of SLAD, I noted that many of the synergies were a direct result of putting several scientific and engineering disciplines together. I believe that multidisciplinary structures will be the wave of the future as we continue to reengineer. We must avoid single-discipline stovepiping! Organizations which employ, for example, solely atmospheric physics or solely operations research analysis will be inherently less disciplined, less efficient, and less balanced than multidisciplinary organizations like SLAD. Stovepipe organizations are less disciplined because they are not intrinsically forced to consider which skill sets should be brought to bear on a given problem. They are less efficient, because they are inherently unable to realize the technical and administrative synergies that can occur in an organization with multiple areas of expertise. Finally, stovepipe organizations are less balanced because to their hammer, every problem appears as a nail.

My final generic lesson is that we in the Defense Department can no longer afford the luxury of separate "white hat" and "black hat" organizations. Moreover, to have some organizations which help PMs and others which judge PMs is not only expensive, it flies in the face of currently ascendant management theory.

Before Defense Downsizing, PMs had to pay for survivability help; the Army staff also had to provide mission funds for survivability assessments. Now, increased recognition that separate helpers and assessors are not affordable has led to substantive dollar savings for the DoD. An ironic consequence is that while SLAD is hard at work playing *both* roles with the same resources, the two sets of proponents are each suggesting that the other should pay the bill. One undesirable consequence of this situation is that SLAD senior management has been required to spend an inordinate amount of time on funding issues. Over time, this has led to strong support for both our missions at HQDA.

Current management theories of quality indicate that if we have flawed output from a business process we should fix the process, not hire additional checkers to monitor the flawed output. In SLAD, we saw above that the goal is to help PMs throughout the acquisition process while simultaneously feeding objective assessments into the RDA decision process as needed. This is simply a better way to reengineer the process than providing a lot of black hat checkers; SLAD's success proves that point.